JOURNAL

OF

HELMINTHOLOGY

Edited by

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Vol. XIV. 1936.

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Paronchocerca ciconiarum n.g., n.sp. from the Saddle-billed Stork in West Africa.

By B. G. Peters, M.Sc., Ph.D.

(*From the Department of Helminthology, London School of Hygiene and Tropical Medicine.*)

At the post mortem examination of a Saddle-billed Stork which died at the London Zoological Gardens, filarial worms were found in the heart and pulmonary artery. These parasites were forwarded for identification to Prof. R. T. Leiper, to whom I am indebted for the opportunity of examining and reporting upon the filariid and for assistance regarding the relevant literature.

Description.

The material consists of three complete males, two complete females, a few fragments, and numerous microfilariae from residual blood in the heart. The males, measuring 40 to 41 mm. by 0·42 mm., are much shorter and narrower than the females which measure 68 to 70 mm. by 0·8 mm. There is a ventral curvature of the body posteriorly in both sexes, the male forming a loose double spiral and the female a single complete loop.

From immediately behind the head to the extreme posterior end the 14 to 20μ thick cuticle bears externally and quite superficially a series of transverse annular rugae. These are somewhat similar to those seen in species of *Onchocerca*, but differ in being markedly irregular in two respects. In the first place the interval between consecutive rugae varies unevenly from 10 to 30μ, a very short interval often being followed by a long one (see fig. 4). Secondly, many of the individual rugae are quite short, extending for only (say) one-tenth of the body circumference. All rugae are interrupted at the lateral lines, those on one side of a line not corresponding in alignment with those opposite. Between the rugae there are extremely fine transverse striae, 4 to 5μ apart. These are to be seen clearly only at the edge of the specimen and are more obvious in the posterior half of the body. The rugae and striae differ further from those in *Onchocerca* in being quite superficial, whereas in the latter genus they involve the whole thickness of the cuticle, so that the underlying body

wall is thrown into annular corrugations. In addition to the transverse striae there are also fine longitudinal striae visible only at the edge. It is difficult to estimate the true interval between them, but as seen in optical projection at the edge of the specimen they appear to lie about 7μ apart. The above cuticular characteristics apply equally to both sexes.

The head, which is very flat, measures about 0·1 mm. in diameter in the female and about 0·08 mm. in the male. Immediately behind it there is a very slight constriction, after which the body diameter gradually increases posteriorly. As seen in apical view (fig. 2) the head is square with the sides of the square dorsal, ventral and lateral in position. This shape is due to the presence of four marked submedian prominences, each bearing a single small papilla. What appear to be the openings of the amphids are to be seen laterally. The papillae and amphids are difficult to distinguish even in apical view and are best brought into relief by mounting the head without a coverslip.

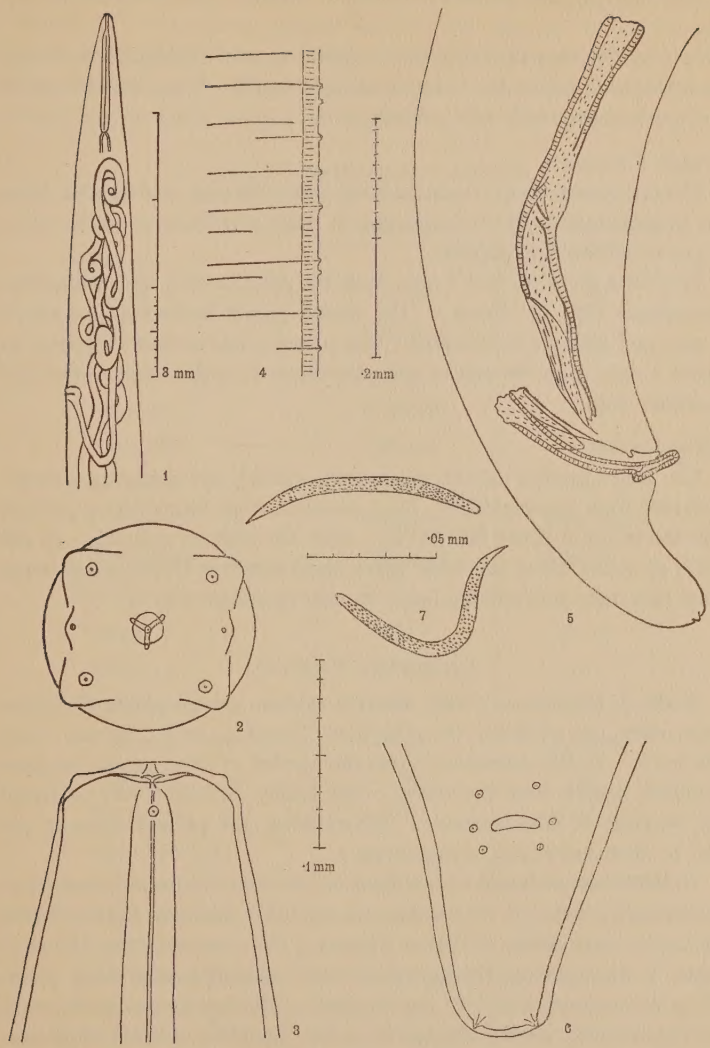
The narrow oesophagus extends for a distance of about 1·5 mm. in the female and about 1·1 mm. in the male. Anteriorly a shorter narrower portion can be differentiated measuring respectively 0·2 mm. and 0·16 mm. in length. The diameters of the two sections are in the female 0·03 mm. and 0·1 mm., and in the male 0·02 mm. and 0·07 mm. Laterally are large glands which apparently open into the mouth.

The nerve ring and excretory pore have not been distinguished with certainty, but immediately behind the head there is a faint indication of what may be the excretory pore. No cervical papillae have been observed. The intestine is of about the same diameter as the posterior oesophagus.

Male characters.

The tail is about 0·13 mm. long and is bluntly rounded. It bears subterminally a pair of papillae which appear to be the openings of caudal glands. The spicules are unequal in size and dissimilar in shape. The longer left spicule measures 340 to 370μ by 35μ and shows a twist at about half its length (fig. 5) ; it ends in a point. The right spicule has the shape of a Wellington boot, measures 160 to 170μ by 28μ, and has a rounded posterior end. At the edges, where the spicule wall is seen in

Paronchocerca ciconiarum, n. g., n. sp. Fig. 1. Female, anterior end, lateral view. Fig. 2. Female head, apical view. Fig. 3. Female head, lateral view. Fig. 4. Female, rugae and striae. Fig. 5. Male, posterior end, lateral view. Fig. 6. Male, posterior end, ventral view. Fig. 7. Microfilariae.



Paronchocerca ciconiarum, n.g., n.sp.

optical section, transverse striation is obvious. There is no accessory piece.

In a lateral view no ano-genital papillae can be distinguished, but in ventral view it is possible to see three pairs (fig. 6). They are very small and are best seen without a coverslip.

Female Characters.

The tail is very short, the anus lying from 0·08 mm. to 0·11 mm. from the posterior end. The tail is conical in shape and bears, as in the male, a pair of subterminal papillae.

The vulva lies 4·25 to 4·7 mm. from the anterior end, well behind the oesophagus (fig. 1). From it, the vagina passes backwards for about 1 mm. and then turns forwards. The uterine coils extend anteriorly to about 1 mm. from the mouth and posteriorly to within 3 mm. from the posterior end.

Microfilariae.

The heart cavities of the stork were washed, and microfilariae were obtained from the washings. They are short stout forms with a pointed tail and measure about 92μ by 5μ ; they are without a sheath. In the mass of nuclei filling the body space, gaps occur at the so-called nerve ring, excretory pore and anal pore in most specimens (fig. 7).

Systematic Position.

Yorke & Maplestone (1926) describe thirteen genera of the Filariidae from birds, one of them, *Splendidofilaria* Skrjabin, 1923 (Loainae), from the heart. In the intervening years the number of avian genera has been doubled, judging from the survey of the family recently (1936) published by Skrjabin & Schikhobalova. Nevertheless, the present material can not be allocated to any of these genera.

In 1880 Manson described two filarias from birds, one from the semilunar valves and arteries of *Pica media* and the other from the right ventricle and pulmonary artery of *Corvus torquatus*. In communicating Manson's letter to the Quekett Microscopical Club, Cobbold named these worms *Filaria picae mediae* and *F. corvi torquati*. The former was described as having cuticular bosses, and therefore may have been a *Splendidofilaria* ; the latter had a smooth cuticle. Both species were considerably smaller than the present material.

The presence of cuticular rugae immediately suggests the genus *Onchocerca*. This genus already contains one species, *O. bambusicolae* Hsi-Chieh Li, 1933, from the body cavity of *Bambusicola thoracica*, the Chinese Bamboo Partridge (Galliformes), to which the present species shows considerable resemblances. From the description given by

Principal Dimensions (in millimetres).

	O. bambusicolae.	Present material.
MALE—		
Length	31–35	40–41
Width	0·25–0·35	0·42
Oesophagus—		
1st part	0·43–0·45	0·16
2nd part	3·85–4·0	0·96
Tail length	0·13–0·15	0·11–0·15
Left spicule	0·19–0·21	0·34–0·37
Right spicule	0·14–0·15	0·16–0·17
FEMALE—		
Length	53	68–70
Width	0·7	0·8
Oesophagus—		
1st part	0·50	0·20–0·23
2nd part	5·86	1·34
Tail length	0·12	0·08–0·11
Vulva from head ...	4·0	4·25–4·70

Hsi-Chieh Li, however, it is by no means certain that his species should be placed in *Onchocerca*. It is not clear whether the cuticular rugae and striae show those differences from the corresponding structures in *Onchocerca* which have been discussed above, but the mere presence of rugae is not itself a generic character. They have been described, for example, in *Hastospiculum onchocercum* Chitwood, 1932, a genus far removed from the Onchocercinae.

In *Onchocerca* the head bears eight submedian papillae arranged in two rings, judging from Sandground's (1934) figure of *O. caecutiens*. *O. bambusicolae* and the present species have only four submedian papillae. The male tail of *O. bambusicolae*, as Hsi-Chieh Li points out, is more like that of *Elaeophora poeli*, and the same is true of the present species. *E. poeli* Railliet & Henry, 1912, is parasitic in the aorta of ruminants and is described as having transverse striations and also marked annulations lying at a deeper level; the posterior portion of the female hanging free in the lumen of the aorta is five or six times as wide as the anterior portion lying buried in the wall. In *O. bambusicolae* and the present species the annulations are entirely superficial, and the female does not show marked differences in diameter along its length.

Hsi-Chieh Li describes rod-like cuticular thickenings on the ventral caudal part of the male, and he likens these to the fusiform thickenings distributed irregularly over the cuticle of *Onchocercella katangensis* (Gedoelst, 1916) Yorke & Maplestone, 1931. His figure shows that these rod-like thickenings are longitudinal in direction, whereas the fusiform thickenings of *Onchocercella* are transverse, and appear to be homologous with rugae, which are not otherwise represented. It seems likelier that the incomplete rugae found in the present material are more closely allied to the *Onchocercella* thickenings. Longitudinal thickenings have not been found in the present material. Sandground (1934) states that he has examined the types of *O. bambusicolae* and holds that the species should be removed from *Onchocerca*.

As mentioned above, the present material closely resembles *O. bambusicolae*. It differs from that species, however, in several minor respects which will best be seen in the accompanying table of measurements. Here it will be obvious that the present worms are larger, have a much shorter oesophagus, and in the male have a much larger left spicule. In addition, there are three pairs of adanal papillae instead of four, and there are no longitudinal thickenings.

The present material is here regarded as constituting a new species for which a new genus must be erected, and the name *Paronchocerca ciconiarum* n. g., n. sp. is proposed. The genus is considered to fall with the subfamily Onchocercinae Leiper, 1911, and to show resemblances to each of the three genera hitherto included in that subfamily.

PARONCHOCERCA n. g.

Generic Diagnosis.

Onchocercinae ; both sexes filiform, the female not being distended posteriorly. Mouth devoid of lips, surrounded by four submedian papillae. Cuticle in both sexes bearing externally transverse rugae and fine striae. Oesophagus divisible into a shorter, narrower, anterior portion and a longer, wide, posterior portion. A pair of terminal caudal papillae in both sexes. Male : caudal alae absent ; ano-genital papillae restricted to three or four small adanal pairs ; spicules unequal and dissimilar, without an accessory piece. Female : considerably larger than the male ; the vulva some distance (at least 4 mm.) from the anterior end and the vagina and uteri extending anterior to it. Microfilariae : short and stout without a sheath. Parasites of the blood vessels and body cavity of birds.

Type Species.

P. ciconiarum n. sp., with the characters described in the preceding pages. From the heart and pulmonary artery of storks.

Type Host.

Ephippiorhynchus senegalensis, Saddle-billed Stork or African Jabiru (Ardeiformes) from West Africa.

A single fragment of a filarial worm, fortunately a male tail, was recovered from the heart of a White-necked Stork, *Dissoura episcopus*, which died at the London Zoo in 1933. This fragment reveals exactly the same structure as the male tail of *P. ciconiarum*, so that *Dissoura episcopus* is also a host. The specific name *ciconiarum* is based upon the fact that both of the bird hosts are storks belonging to the suborder Ciconiae of the Ardeiformes.

Other Species.

The species *Onchocerca bambusicolae* is so closely similar to *Paronchocerca ciconiarum* that it is hereby transferred from *Onchocerca* to *Paronchocerca*.

The Subfamily Onchocercinae Leiper, 1911.

Skrjabin & Schikhobalova (1936) suggest that the Onchocercinae may prove to be an artificial group, and that the cuticle of the contained species should be submitted to detailed study. The inference is that transverse

cuticular structures (rugae, deep-lying annulations, fusiform bosses), found in addition to fine striae, constitute the sole characteristic common to the group. Cuticular structures of this kind are not now to be relied upon as of subfamilial or even generic importance, and the above authors have, for example, suppressed the Loainae altogether on this ground. However, other structures of diagnostic value seem to conform to a general plan in the various genera of the Onchocercinae. Thus the spicules are broadly similar throughout the group, except perhaps in *Onchocercella* where they are subequal in size. Both cephalic and anogenital papillae show similarities, in these two respects *Onchocerca* standing rather apart from the others. In any event, no revision of the subfamily can usefully be attempted without a study of the contained species, many of which are difficult of access.

Provisionally accepting the present subfamily, it would seem possible to differentiate the contained genera on the basis of cephalic papillae, male ano-genital papillae, and cuticular structures, as follows.

1 *ONCHOCERCA* Diesing, 1841.

Cephalic papillae : eight submedian papillae arranged in two concentric rings.

Anogenital papillae : usually four adanal pairs with a variable number of postanal pairs and occasionally also one or two preanal pairs. (Although fundamentally arranged in pairs, the right or left member of any pair may be suppressed, thus giving rise to considerable variation within a single species and suggesting that the papillae are in course of reduction to a pattern like that in the other genera.)

Cuticular structures : external annular rugae at more or less regular intervals, with fine transverse striae at shorter intervals between them. These structures involve the whole thickness of the cuticule so that the underlying body wall has a corrugated appearance. The rugae are interrupted at the lateral lines, those on one side of a line corresponding in alignment with those opposite.

Genoptye : *O. reticulata* Diesing, 1841.

Sandground (1934) has suggested, without making a formal proposition, that many of the species should fall into synonymy. If this were done the valid species would be as follows :—

O. armillata Railliet & Henry, 1909.
O. fasciata Railliet & Henry, 1910.
O. flexuosa (Wedl, 1856.)
O. gibsoni Cleland & Johnston, 1910. (Syn. *O. indica*).
O. gutturosa Neumann, 1910. (Syn. *O. bovis*)
O. lienalis (Stiles, 1892.)
O. reticulata Diesing, 1841. (Syn. *O. cervicalis*)
O. volvulus (Leuckart, 1893.) (Syn. *O. caecutiens*)

The following are of uncertain position :—
O. caprae (Linstow, 1883)
O. fuelleborni Hoeppli, Hsü & Wu, 1929.
O. spiralis (Molin, 1860.)

Sandground is further unable, on purely morphological grounds, to separate the four species *flexuosa*, *gibsoni*, *lienalis*, and *volvulus*. He rightly states that the original description of *O. fasciata* was totally inadequate, but apparently had not seen the redescription (including a male tail) by Henry & Masson (1933). He omits *O. caprae* and *O. spiralis* from his review.

2 *PARONCHOCERCA* n. g.
Cephalic papillae : four, submedian and concentric.
Anogenital papillae : three or four adanal pairs.
Cuticular structures : superficial annular rugae, often at irregular intervals and many of them short (incomplete), with fine transverse striae at shorter intervals between them. These structures are quite superficial and do not involve corrugation of the body wall. The rugae are interrupted at the lateral lines, those on one side of a line not corresponding in alignment with those opposite (at least in the genotype).
Genotype : *P. ciconiarum* n. sp.
Other species : *P. bambusicolae* (Hsi-Chieh Li, 1933.)

3 *ELAEOPHORA* Railliet & Henry, 1912.
Cephalic papillae : ?
Anogenital papillae : five adanal pairs.
Cuticular structures : fine transverse striae superficially and annulations lying at a deeper level.
Monotype : *E. poeli* (Vryburg, 1897.)

4 *ONCHOCERCELLA* Yorke & Maplestone, 1931.

Cephalic papillae : four, submedian and concentric.

Anogenital papillae : six adanal pairs.

Cuticular structures : transverse fusiform thickenings distributed irregularly and fine transverse striae.

Monotype : *O. katangensis* (Gedoelst, 1916.)

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Journal of Helminthology, Vol. XIV. *No.* 1, *March*, 1936, *pp.* 11–20.

The Action of Certain Halogen Compounds on the Potato Eelworm, *Heterodera schachtii.*

By Enid M. Smedley, M.Sc.

(*From the Department of Helminthology, London School of Hygiene and Tropical Medicine.*)

Considerable work has been done in Germany in recent years on the use of bleaching powder in controlling the sugar-beet strain of the nematode *Heterodera schachtii*. Laboratory work with a view to discovering the manner in which the chemical affects the nematode has been carried on extensively for some years by Molz, who concludes that the nematodes are stimulated to hatch by the supply of an abundance of oxygen, and are furthermore thigmotactically attracted and killed, so that, in the absence of suitable host plants, a large proportion of the nematode population may be destroyed.

The author has had opportunity, through a grant from Imperial Chemical Industries, Limited, of investigating numerous chemicals from the standpoint of eelworm control, among them bleaching powder and numerous related substances. Molz's earlier work not being known, the problem was tackled from an entirely new angle and several points have come to light which might otherwise have remained obscure. It is hoped this information will throw some light on the problem as a whole.

Opportunity is here taken of tendering sincere and grateful thanks to Professor R. T. Leiper who has very graciously sponsored and supervised the work, and who has been unfailingly kind, interested and helpful.

Molz worked with 16 per cent. bleaching powder, *i.e.*, presumably containing 16 per cent. of available chlorine. With solutions made up by weight, he found that dilutions of from 0·01% to 0·0005% (1/62,500 to 1/1,250,000 available chlorine) greatly stimulated the hatching of larvae from cysts of the sugar beet nematodes. His subsequent work was done at similarly high dilutions in an attempt to find an explanation of this phenomenon.

In the present work, on the other hand, all chemicals supplied have first been tested at a 1% dilution, as the simplest way of eliminating

those substances of no nematocidal value. Accordingly, when a sample of sodium hypochlorite liquor was presented, a solution containing 1% of available chlorine was prepared and into it were placed free-living nematodes, of the species *Rhabditis broughton-alcocki* and *Cylindrogaster coprophaga*, as a preliminary test. Within a few minutes the worms were seen to dissolve completely. A piece of dried *Ascaris* cuticle, of a very resistant nature, was similarly dissolved in time. It is well known that the cyst wall of *Heterodera schachtii* is phenomenally resistant to chemical actions of all kinds, concentrated sulphuric acid being the only chemical known to attack it. On the assumption that this really consists of a modified cuticle, some cysts, of the potato-strain, were next placed in the solution. They were observed to behave in exactly the same way as the nematodes and the piece of dried cuticle. There were first of all a few bubbles around the edges with a slight bleaching of the brown colour, then the cyst became filled with bubbles, and, the cyst-wall meanwhile softening and dissolving away, the whole cyst finally broke open, discharging its content of embryonated eggs into the solution. The following table shows the times necessary to accomplish this at various strengths :—

Table I.

Available chlorine	1%	1/250	1/500	1/750	1/1,000	1/2,500	1/5,000
Time taken to dissolve cysts ...	½ hr.	1½ hrs.	3½ hrs.	5 hrs.	7½ hrs.	48 hrs.	72 hrs.

It is worthy of passing mention that solutions of sodium hypochlorite do not dissolve the delicate membrane surrounding the individual eggs, but this is nevertheless permeable to the solution, as the coiled larvae within are slowly dissolved.

In seeking an explanation of this hitherto unrecorded phenomenon, many classes of substances were examined. The strong mineral acids, hydrochloric, nitric and sulphuric, were tried and also acetic acid. As stated above, sulphuric acid was effective, leaving only a few charred remains, obviously a different type of action. Eighteen hours' exposure produced no effect with the other three, but with the hydrochloric there was bleaching. Of course, it will be understood that the point of interest here was not the viability of the cyst contents, which must certainly

have been affected, but merely whether or not any of these acids exerted a solvent action on the cyst wall.

A survey was now made of the various chemical properties of the solution which might be responsible for its action. It was first of all quite strongly alkaline, and contained a substantial amount of common salt in solution ; also, it was capable of giving off chlorine and, lastly, of acting as an oxidizing agent. A 15% solution of caustic soda was tested overnight for the possible action of the alkaline property, but apart from the general softening which caustic solutions always produce in organic tissue, the cysts remained unchanged. A saturated solution of common salt, NaCl, produced no effect at all. Various oxidizing agents were then tried, including hydrogen peroxide, potassium chlorate, potassium permanganate, sodium periodate, all in concentrated form, but without result. Numerous compounds capable of liberating free chlorine were tested ; including chloramine T, succinchlorimide, high strength calcium hypochlorite, chlorine water, azochloramide. None of these was effective except the calcium hypochlorite, which formed suspensions in water and behaved very similarly to the sodium hypochlorite. It was, therefore, concluded that the solvent action is a special property of the hypochlorite radical, a view supported by the following statement (Dakin, etc., 1916)—" The action of hypochlorites upon proteins consists, at least in part, in the replacement of the hydrogen of some of the (NH) groups by chlorine, thus forming substances of the chloramine group."

Especially interesting is the failure of chlorine water to show this action, for it of course, contains a dilute solution of hypochlorous acid. The reaction apparently occurs only in alkaline solution.

That the degree of alkalinity is of little or no importance was clearly shown by a test of four sodium hypochlorite solutions, all of approximately 14% available chlorine, but with total alkali varying from 2% to 0·44% (the latter about the same as the original sample). Tested through the same range of dilutions as before, these solutions showed no differences in time of solution of the cysts which could not be ascribed to the variability of the eelworm cysts themselves, always very noticeable. (It may be mentioned here that in all solution tests, 10 cysts are placed in each sample to be tested, and the recorded time is that of the breaking down of the most resistant).

There was, however, a very noticeable decrease in the amount of gas evolved in the more strongly alkaline solutions, so that in the strongest no bubbles formed at all, the action proceeding entirely by slow solution of the cyst walls. From the odour which always accompanies the reaction, it is presumed this gas is largely chlorine, which is absorbed by the excess alkali.

At first it was hoped that this solvent power might be of practical use in the field against eelworm. Mixing a few ccs. with soil soon showed, however, that owing to its instability, its power was lost. Several preparations containing hypochlorite were tested, nevertheless, in the hope that some forms might be sufficiently stable to be of practical value. Following is a list of the chemicals tested at various times, with their available chlorine content :—

1. Chloros 10%
2. Sodium hypochlorite detergent ... ... 2·5%
3. Tropical bleach ... ... 34·7%
4. Chamber bleach ... ... 38·4%
5. Calcium hypochlorite (high strength) ... 73·2%
6. Basic calcium hypochlorite ... ... 38·5%
7. Calcium hypochlorite liquor ... ... 7·32%

Table II shows the times of solution of cysts in various dilutions of these substances. Nos. 3 to 6 are powders, only slightly soluble in water, it being necessary to shake the suspension well to obtain the desired content of available chlorine.

Pot experiments have been performed with substances 2 to 6, to determine if they can dissolve cysts in contact with soil, or prove beneficial in any way. As it proved inexpedient at that time for this work to be done personally, I wish to take this opportunity of expressing sincere gratitude to Dr. M. J. Triffitt and Dr. R. H. Hurst who carried out the entire set of experiments and have very kindly communicated their results to me.

Each chemical was applied at the rates of 5, 10, 15, 20 and 40 cwts. per acre, to infected soil, well mixed and watered. A few days later, a potato was planted in each pot and also in pots of similar untreated

soil as controls. As it was then late in the growing season (July), little can be concluded from the actual growth of the plants, although cases of sturdy growth in some of the heaviest treatments indicate that the chemicals are not harmful to potatoes. Counts of the cysts newly formed along the roots at the soil-pot surface are so varied and confusing as to offer scant evidence on the matter of control, but an attempt will be made to explain this farther on in the present paper.

TABLE II.—*Showing the times in hours for the solution of cysts of potato eelworm by various chemicals.*

No.	Substance	Dilution in terms of available chlorine						
		1%	1/250	1/500	1/750	1/1,000	1/2,500	1/5,000
1	Chloros ...	½	1	3	5	18	24	30
2	Detergent ...	—	1	2	3½	4	24	48
3	Tropical bleach	6	4	4	6	18	22	40
4	Chamber bleach	7	6	4	4	18	22	22
5	Calcium hypochlorite	1½	1½	2½	4	7	20	24
6	Basic Ca. hypochlorite ...	1½	2	4	7	24	30	48
7	Ca. hypochlorite liquor ...	½	1	1¾	3½	5	15	18

Meanwhile, tests had been continued with the sodium hypochlorite liquor to determine whether dilutions too high to dissolve the cysts might yet prove lethal to the contents. For this purpose, solutions of 1/5,000 to 1/100,000 available chlorine were prepared and into each were placed 75 cysts, previously soaked in water. Twenty-five cysts were removed at the end of 24, 48 and 72 hours, well rinsed in water and placed in watch-glasses with tap water and potato-root excretion. With the exception of the 1/5,000 solution, which killed practically all

the eggs, there was a general and very noticeable increase in rate of hatching, as compared with the controls, which consisted of soaked, untreated cysts in tap water and root excretion. Table III gives a summary of the hatching results, during the first six weeks.

It will be remembered that sodium hypochlorite did not attack the egg membrane. During the series of tests, summarized in Table II, however, it was noticed that all substances whose active principle is calcium hypochlorite do attack this membrane with the result that a majority of the larvae are liberated into the solution. At the strengths so far tested, of course, these free larvae could not usually survive, even

TABLE III.—*Showing the number of larvae hatching in six weeks from* 25 *cysts after treating for various periods of time with various dilutions of hypochlorite.*

Exposure	Total	1/5,000	1/7,500	1/10,000	1/15,000	1/20,000	1/25,000	1/50,000	1/75,000	1/100,000
24 hrs.	1,999	55	347	615	354	209	102	57	64	196
48 hrs.	1,712	25 dead	175	241	543	266	162	72	164	64
72 hrs.	1,256	8 dead	36	327	314	143	257	40	54	77
Totals : (75 cysts)	Grand total 4,967	88	558	1,183	1,211	618	521	169	282	337
Average per cyst ...	7·36	1·17	7·87	15·8	16·15	8·24	6·94	2·25	3·76	4·5

Controls averaged 1·32 larvae per cyst.

if they were alive when liberated, which is doubtful. It seemed possible, however, that tests with higher dilutions might disclose a method of persuading the larvae to hatch in great numbers without the use of root excretion. From the point of view of control this is just as important as killing the larvae, since the larvae have no means of survival if they are induced to hatch in the absence of any suitable host.

Calcium hypochlorite liquor was selected as being the easiest to use in this experiment. A series of solutions was prepared, with available

chlorine ranging from 1/4,000 to 1/50,000. Into each solution in a watch-glass were placed 25 cysts. At the end of the first three weeks, root excretion was added to the higher dilutions where activity had not been apparent. At the end of six weeks, hatching largely ceased, and the experiment was discontinued.

Table IV gives a summary of the results, which are even more startling when it is remembered that the experiment was performed in December and January, when ordinary hatching by means of root excretion is practically at a standstill.

TABLE IV.—*Showing numbers of larvae hatching from cysts treated for six weeks with various strengths of calcium hypochlorite.*

Exposure	Totals	Dilution in terms of available chlorine								
		1/4,000	1/5,000	1/7,500	1/10,000	1/15,000	1/20,000	1/30,000	1/40,000	1/50,000
First 3 weeks ...	2,208	783	467	949	3	0	5	1	0	0
Second 3 weeks	2,736	713	672	843	73	root excretion added 24	300	54	33	24
Total	4,944	1,496	1,139	1,792	76	24	305	55	33	24
Average per cyst	21·8	60	45·6	71·7	3	1	12·2	2·2	1·3	1
Condition ...		nearly all dead	many alive	nearly all alive			alive			

These experiments, showing the hatching stimulus of hypochlorite, throw some light on the confusing results of the pot experiments already mentioned. The experiments were performed in the hope that the cysts might be dissolved in the soil, and infection thus prevented. We see now, however, that strengths insufficient to kill the eggs have the opposite

effect of stimulating them to hatch more freely. We have also seen that in contact with soil and moisture, these chemicals deteriorate fairly rapidly. We should expect, then, on planting potatoes in freshly treated soil, to find every conceivable grade of effect, from control in some cases to increased infection in others, with probably the majority but little different to the untreated plants. A clear understanding of the problem suggests the adoption of the method evolved in Germany from quite different considerations, *i.e.*, application of the chemical to soil free from host-plants, and planting of the susceptible crop only after sufficient time has elapsed for destruction of most of the larvae. Even then, only a measure of control could be hoped for, for it would be impossible in the field to exhaust the cysts entirely, and the viable eggs remaining would be capable of setting up a new cycle of infection.

It is interesting at this point to consider Molz's experiences and conclusions. It has been stated above that he worked only with very dilute solutions, and consequently was unaware of the solvent power of concentrated solutions. He attributes the enormously increased rate of hatching he observed to a physiological stimulus, and indeed cites several instances of substances used as stimulants in human medicine, which also exert a stimulating effect on *Heterodera* cysts. Believing this stimulus to be due to the property possessed by chloride of lime of liberating free oxygen, combined with its alkaline nature, he illustrated his argument by enumerating chemical and physiological reactions in which oxygen is evolved only when the medium is kept alkaline, as for instance in the blood. Accordingly, he performs hatching experiments with mixtures of potassium hydroxide and hydrogen peroxide, and with terpestrol soap, the latter capable of absorbing oxygen from the atmosphere in the form of ozone, and giving it up again to other bodies. Actually with some of these substances he has obtained rates of hatching showing a decided increase over his untreated controls, but never to anything like the same degree as with bleaching powder. Doubtless alkaline substances which give off free oxygen are possessed of some degree of stimulating power, but we are firmly convinced that the enormous activating power of bleaching powder belongs in large part to its special property of attacking proteins.

Reference may be made to the use of " Milton " fluid to induce exsheathing of third stage larvae of parasitic nematodes of sheep, as

described by Lapage (1933). He uses a 1 : 20 dilution, which brings about ex-sheathing in 20 minutes or less at laboratory temperature and in which the larvae survive several days, although stronger solutions injure or destroy them. He finds this property to be peculiar to solutions containing hypochlorite, which seems to indicate again that the phenomenon is a function of the special properties of this group of substances. "Milton" has been tested for its power of dissolving potato eelworm cysts, and has proved to be comparable to other solutions of sodium hypochlorite.

Special thanks are accorded to Mr. R. M. Winter, of Imperial Chemical Industries, Limited, who has given much valuable help and technical advice on the chemical problems involved.

Conclusions.

1. Solutions containing hypochlorite, through their power of attacking proteins, can dissolve the cysts of *Heterodera schachtii*, as well as other forms of nematode cuticle.

2. Solutions too dilute to dissolve the cysts can stimulate the larvae to hatch at an enormously increased rate.

3. Hypochlorite solutions containing calcium can attack the egg membrane, so that the larvae can be induced to hatch without the presence of any natural stimulants, such as root excretion. They can, therefore, be employed to cause hatching in the absence of suitable host plants, thus reducing the infection.

4. The power of hypochlorites to stimulate the hatching of *Heterodera schachtii*, is not merely a function of their action as alkalis and as oxidising agents, but is largely due to their peculiar action on proteins.

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Journal of Helminthology, Vol. XIV, *No.* 1, *March,* 1936, *pp.* 21–40.

Some Observations on the Effect of Digestive Juices on Scolices of *Echinococcus granulosus* (Batsch).*

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Introduction.

The experiments described in this paper were undertaken to study the effect of the digestive juices of certain naturally immune and also certain susceptible animals to infestation with *E. granulosus* by using the scolices of hydatid cysts of sheep and cattle, in order to determine a correlation between natural immunity and the digestibility of scolices of hydatid cysts in the alimentary tract of the particular animal. Very little as yet is known concerning the factors controlling host-parasite specificity. In studies on natural immunity, the majority of investigators have trod the beaten track of immunology and have looked for agglutinins, precipitins, complement fixing antibodies, opsonins, lysins and phagocytosis. It is only within the last decade that there has been a widespread interest to study the effects of non-specific factors on resistance or susceptibility to helminthic infestations.

Natural immunity may be resistance to primary infestation or a mere inhibition of the development of the worm to maturity. Resistance to primary infestation and resistance to the continued accumulation of secondary infestations are more or less distinct from each other. Resistance to primary infestation, or natural immunity, in *seusu stricto*, is a well known phenomenon in parasitology as in bacteriology. There are many instances in which a particular parasite is able to infect only one of two closely related hosts, and there are also numerous instances of closely related parasites of the same genus, one of which is capable of infecting a particular host while the other is not. Host-parasite specificity, however, is no longer considered operative within narrow limits as it was supposed to be. There are many instances where a parasite can infect hosts belonging to entirely different genera, though usually not with equal facility. The factors which determine what host a particular parasite can infect, and what parasites a host can harbour are only imperfectly known.

* I am indebted to Dr. E. L. Turner of this University for advice and assistance during the investigation.

It has been shown by Steiner (1925) and others that the determining factors enabling a parasite to grow and reach maturity in one host and not in another, are capable of alteration by both parasite and host.

Age is a factor in natural resistance operative against some of the helminths, and according to Sandground (1929) this type of immunity, not associated with past or present infection or contact with the derivatives of the parasite, is a characteristic of abnormal hosts. He believes that physiological differences of the hosts become more divergent and accentuated with advancing age, so that the crucial condition which makes it difficult or impossible for a parasite to develop in a given host and not in another, is acquired at or near maturity. Age resistance may or may not be connected with past infection. Herrick's (1925) experiments on the nematode *Ascaridia lineata* of the chicken demonstrated conclusively that age resistance was not connected with past infection. Age immunity in normal hosts was demonstrated by Ransom and Foster (1920) on *Ascaris* in pigs, by Herrick on *Ascaridia* of chickens, by McCoy (1931) on *Ancylostoma caninum* in dogs, and by Sarles (1929) on *A. braziliense* in cats.

Vitamin deficiency lowers resistance to helminthic infestations. Hiraishi (1926) and Koidzumi (1927) found that diets deficient in vitamin A increased the susceptibility of pigs to pig strain of *Ascaris lumbricoides* as well as to the human strain which generally fails to mature in pigs. Ackert, Fisher & Zimmerman (1927) and Ackert, McIlvaine & Crawford (1931) found that vitamin A deficiency as well as vitamin B deficiency (Ackert & Nolf, 1931) increased the susceptibility of chickens to *A. lineata*, while vitamin D deficiency did not appear to have such an effect (Ackert & Spindler, 1929). Ackert and Beach (1933) showed that chickens on the best diet had the fewest and shortest *A. lineata*. Ackert (1925) and Porter & Ackert (1933) demonstrated that blood letting also lowered the resistance of the chickens to *Ascaridia*. In discussing age resistance to the nematode *A. lineata*, Porter & Beach (1935) concluded that the explanation of their experiments as well as of others on this subject did not lend itself to the " abnormal host " theory of Sandground nor to that of " development stimulating factor " theory of Fülleborn (1930). They could best be explained by the " growth-inhibiting substance " theory of Carrel and Ebeling (1921). According to these authors age resistance is characterised by a proportionate increase in the growth

inhibiting factor and not by a decrease in the growth accelerating substance.

A number of investigators have endeavoured to demonstrate a relationship between endocrine deficiency and susceptibility to helminthic infestations. Ackert (1924) found that parasitism reduced disproportionately the thymus glands of fowls, but Herrick found no increased susceptibility in thymectomised chickens to the development of *Ascaridia*.

Although the factors which determine what host a particular parasite can infect and what parasites a host can harbour are imperfectly known, still some of these factors are capable of alteration by both host and parasite. This is especially true in races of parasites which differ from each other in their ability to mature in different hosts. *Strongyloides stercoralis* of man, dogs and cats, *Necators* of man and pigs, *Ascaris* of pigs and man belong to this category. It has been shown, however, that the hostal relations of certain parasites can be altered by growing them generation after generation, in a new host. Taylor (1928) demonstrated that the infectivity of gapeworms of starlings to chickens was markedly increased after one generation in the chickens, and Chandler (1932) showed that a *Trichostrongylid* parasite of wild rats, *Nippostrongylus muris*, which could originally produce infestation of short duration in laboratory rats and mice, after some thirty or forty generations in white rats acted differently, and produced more persistent infestations.

Very few investigators have turned their attention to the study of the effects of the digestive juices of the host's body in its bearing on natural immunity. Andrews (1927) in a study of coccidia of mammals found that in the normal host the digestive processes facilitated excystation of the oöcysts, whereas in an abnormal host it allowed the oöcysts to pass unchanged through the intestines. Thomson & Robertson (1926) showed specifically that oöcysts of fish coccidia can be ingested with the food, pass through the alimentary canal, and be excreted in the faeces of man in an unchanged condition. Yenikomishian and the author (1934) showed that ova of *Fasciola hepatica* and *Dicrocoelium dendriticum* could pass through the alimentary tract of dogs and man unchanged. We are studying the effect of the digestive juices of various animals on the eggs of cestodes. The results will be published separately.

As there is such a wide difference in the diet of different animals and even in the anatomical make up of their alimentary tracts, it is possible

that the digestive juices of one animal may be capable of rapidly digesting the larval stage of a helminth while those of another animal may be entirely ineffective. There is also the possibility that the digestive juices of one animal may be effective against one type of helminth and not against another. Therefore, the part played by digestive juices may be one of the most important factors in determining host parasite specificity. It is difficult to conceive that the digestive juices should have no influence in any case of successful parasitism in which the parasite, in one stage or another of its life cycle, has to pass through the alimentary tract.

Materials and Methods of Study.

1. Scolices of hydatid cysts.
2. Artificial gastric juice and artificial pancreatic juice.
3. Gastric and duodenal juices of man.
4. Gastric and intestinal juices of dogs, kittens, sheep and cattle.
5. Bile from sheep, cattle and kittens.

Scolices from liver and lung cysts of sheep and cattle were obtained from the slaughter house. Only viable, fresh (actively contracting) scolices from fertile cysts were used in the experiments. Artificial gastric juice was prepared by dissolving 1 gram of Pepsin (Merck) in 0·4% hydrochloric acid, and artificial pancreatic juice was prepared by dissolving 0·6 gm. of pancreatin (Merck) in 1·25% sodium bicarbonate solution. Both the pepsin and the pancreatin met the requirements of B.P. 1932. Human gastric juice was obtained after a test meal from hospital patients. Only gastric juice with normal hydrochloric acid content was used. Human duodenal juice was obtained by drainage. "Bile A," that obtained immediately on aspiration, was slightly acid in reaction due to admixture with gastric juice. It contained of course the intestinal secretions in addition to bile. "Bile B," that obtained after the emptying of the gall-bladder was alkaline. Gastric and intestinal juices of sheep and cattle were obtained from the slaughter house on the day of the experiment. Dog gastric juice was obtained by stomach tube one hour after a meal. Intestinal juice of dogs and gastric juice and intestinal juice of cats was obtained by straining the contents of the organs through many layers of gauze. The animals were killed one hour after feeding. Bile from sheep, cattle and kittens was obtained by aspirating the gall-bladders, and therefore was not contaminated with intestinal juices.

Methods.

The effect of digestive juices on scolices was studied *in vivo* and *in vitro*.

Experiments *in vitro*:—(Method A). A small amount of hydatid sand containing one hundred or more scolices was placed into 0·1 cc.–0·15 cc. of various digestive juices to be examined on a microscopic slide, 76 by 26 mm. The preparation was covered by a large cover slip 46 by 25 mm., and the borders were sealed with petrolatum to prevent evaporation. The slides were kept at room temperature 24–31°C., were examined at different time intervals and the effect of the digestive juices on the scolices was recorded.

(Method B). A little hydatid sand containing 500–1,000 scolices was placed in small narrow test tubes and 0·5–1 cc. of one of the various digestive juices was added to each tube. The tubes were shaken and incubated at 37°C. At different time intervals some of the contents of each tube was taken out and examined under the microscope. Both of these methods were found satisfactory. The advantage of the former was that one could watch the same microscopic field, hence the same scolices at different times during the process of digestion.

(Controls). Scolices were placed in water, normal saline, in 0·4% hydrochloric acid solution, in 1·25% sodium bicarbonate solution and in 0·5% sodium carbonate solution. The slides or test tubes were examined in the same way as in the protocols.

In vivo experiments were performed on kittens, rats and rabbits. Kittens and rats, when left without food overnight readily devoured scolices and cyst membranes. Rabbits were fed by forcing the material into their mouths. At definite time intervals after feeding, the animals were killed and their intestinal tracts were carefully searched macroscopically and microscopically for the remains of membranes and scolices.

Experimental.

1. *Effect of Artificial Gastric Juice on Scolices.*—On a slide preparation with artificial gastric juice a field containing fifteen scolices was chosen and was kept under observation for a period of twenty-four hours. In artificial gastric juice scolices do not manifest active contraction. The evagination is very gradual and before it is complete digestion sets in.

The evaginated scolices swell, their contour becomes indistinct and their structure granular. The digestion of scolices in artificial gastric juice is incomplete. Scolices do not disintegrate completely even upon prolonged exposure. Certain of the scolices are attacked readily, others are quite resistant. This experiment was repeated many times with different batches of scolices with essentially identical results, the only variation being in the length of time needed for digestion. Those scolices which fail to evaginate are not digested (fig. 2).

TABLE I.

Effect of Gastric Juice on Scolices at 37°C.

Scolices placed in 0·5 cc. of	Result of examination after				
	1 hour.	2 hours.	4 hours.	8 hours.	24 hours.
0·4% Hydrochloric acid (Control)	C− E− D−	C− E+− D−	C− E+ D−	C− E+ D−	C− E+ D−
Dog Gastric Juice ...	C+− E− D−	C+− E− D−	C− E− D−	C− E+− D−	C− E+− D−
Cat Gastric Juice ...	C+− E− D−	C+− E− D−	C− E− D−	C− E− D−	C− E− D−
Sheep Gastric Juice ...	C− E− D−	C− E− D−	C− E− D−	C− E− D+−	C− E+− D+
Cattle Gastric Juice ...	C− E− D−	C− E− D−	C− E− D−	C− E− D+−	C− E+ D+
Human Gastric Juice	C+− E+ D+−	C+− E+ D+	C− E++ D++	C− E++ D++	C− E+++ D+++
Artificial Gastric Juice	C+− E+ D+	C+− E++ D+	C− E++ D+++	C− E+++ D+++	C− E++++ D++++

(Interpretation of signs) :—C=contraction ; E=evagination ; D=digestion ; −=negative ; +−=very slight ; +=slight ; ++=partial ; +++=marked ; ++++=complete.

Note that with human and artificial gastric juice D+++ and D++++ indicate that a great majority or all of the scolices show evidence of digestion, although digestion does not proceed to completion with gastric juice alone.

In the control experiments where scolices were placed in 0·4% hydrochloric acid solution, scolices showed no evidence of digestion. With certain batches of scolices there was slow but considerable evagination, with others there was practically no evagination. Contraction of scolices was slight (Table I).

2. *Effect of Human Gastric Juice on Scolices.*—Gastric juice from five different individuals was used in the test. Human gastric juice was found to act on scolices exactly in the same way as did the artificial gastric juice (Table I). The process, however, was found to be relatively more slow (fig. 3).

3. *Effect of Gastric Juice of Sheep and Cattle on Scolices.*—Gastric juice from four sheep and eight cows was tested on different batches of scolices. Sheep gastric juice was found to have no effect on scolices, whereas cow gastric juice caused slight digestion of some of the scolices, when incubated longer than 24 hours (Table I).

4. *Effect of Gastric Juice of Cats and Dogs on Scolices.*—Gastric juice from four kittens and five dogs was used. Scolices placed in these gastric juices did not evaginate and were not digested (Table I).

Effect of the Intestinal Juices on Scolices.—Before experimenting with the intestinal juices the behaviour of different lots of scolices in saline, distilled water, 0·5% sodium carbonate solution and in 1·25% sodium bicarbonate solution was studied. Scolices placed in 0·5% sodium carbonate solution, or in distilled water showed a marked tendency to evaginate. Along with evagination the scolices manifested violent contraction and relaxation. In saline and sodium bicarbonate solution the tendency to evagination was less but contractions were violent (Table II).

1. *Effect of Artificial Pancreatic Juice on Scolices.*—Scolices placed in this medium showed marked contraction and only a few of the scolices evaginated. There was detectable evidence of digestion only after 16 hours incubation at 37°C. which became more advanced in 24 hours.

2. *Effect of Duodenal Juice of Man on Scolices.*—The action of human Bile A and Bile B (duodenal juice) was found to be qualitatively the same but quantitatively different. This difference was later found to be due to the slight acidity of Bile A, which evidently retarded the action of pancreatin. Alkalinization rendered the action of Bile A comparable to that of Bile B. Human duodenal juice was found to digest the scolices rapidly (fig. 4). Digestion was complete within 8–12 hours (Table II).

TABLE II.

Effect of Intestinal Juices on Scolices at 37°C.

Scolices placed in 0·5 cc.	Reaction of medium	Results of Examination after				
		1 hour	4 hours	8 hours	16 hours	24 hours
Normal Saline (Control)	Neutral ...	C+ E− D−	C+ E+ D−	C++ E+ D−	C+− E+ D−	C− E+ D−
Distilled Water (Control)...	Neutral ...	C+ E+ D−	C++ E++ D−	C++ E+++ D−	C+ E+++ D−	C+− E+++ D−
0·5% Sodium Carbonate sol. (Control) ...	Alk. ...	C++ E++ D−	C++ E++ D−	C++ E+++ D−	C+− E+++ D−	C− E+++ D−
1·25% Sodium Bicarbonate sol. (Control)	Alk. ...	C++ E− D−	C+++ E+ D−	C+ E+ D−	C+− E+ D−	C− E++ D−
Human Duodenal Juice (Bile A) ...	Slightly acid	C+− E+ D−	C+− E+ D+	C− E+ D++	D++++	
Human Duodenal Juice (Bile A) alkalinized	Alk. ...	C++ E+ D+−	C+ E+ D+	C+− E− D+++	D++++	
Human Duodenal Juice (Bile B) ...	Alk. ...	C+ E+ D+−	C− E− D+++	D++++		
Artificial Pancreatic Juice	Alk. ...	C+++ E+ D−	C++ E+ D−	C++ E+ D−	C+ E+ D+	C− E+ D++

TABLE II—*continued.*

Scolices placed in 0.5 cc.	Reaction of medium	Results of Examination after				
		1 hour	4 hours	8 hours	16 hours	24 hours
Sheep intestinal juice	Acid ...	C+− E+ D−	C+− E+ D−	C− E+ D+	C− E+ D+++	 D+++
Sheep Bile	Alk. ...	C+++ E+− D−	C++ E+ D−	C+ E+ D−	C− E+ D−	C− E+ D−
Cattle Intestinal Juice	Acid ...	C+− E+ D−	C+− E+ D−	C− E+ D+	C− E− D++	 D++++
Cattle Bile	Alk. ...	C++ E+− D−	C++ E+ D−	C+ E+ D−	C+ E+ D−	C− E+ D−
Dog Intestinal Juice	Alk. ...	C++ E+ D−	C++ E++ D−	C+ E++ D−	C+ E++ D−	C− E++ D−
Dog Bile	Alk. ...	C++ E+− D−	C++ E+ D−	C+− E+ D−	C− E+ D−	C− E+ D−
Cat Intestinal Juice	Alk. ...	C++ E+ D−	C++ E+ D−	C+ E+ D−	C− E+ D−	C− E+ D−
Cat Bile	Alk. ...	C++ E+− D−	C++ E+ D−	C+ E+ D−	C− E+ D−	C− E+ D−

Signs in this table have the same significance as in Table I, except that here D+++ indicates *completion* of digestion.

This experiment was repeated four times with duodenal juice from different patients, always with similar results.

3. *Effect of Intestinal Juices of Sheep and Cattle on Scolices.*—At the time of collection the intestinal juices of sheep and cattle were always found acid in reaction. The acidity was more when the juice was collected from the duodenum than from the ileum. The acidity of the collected fluid gradually increased with lapse of time, no doubt due to bacterial action, therefore only freshly collected fluid was used in the experiments. Intestinal juices from six sheep and twelve cattle were tested. The results were essentially the same (Table II). Both sheep and cattle intestinal juices were capable of digesting scolices *in vitro*. Digestion with sheep and cattle intestinal juices proceeded considerably slower than with the human duodenal juices, digestion being complete in about 24 hours. The slowness of digestion may be attributed to the acidity of the juices.

4. *Effect of Intestinal Juice of Kittens and Dogs on Scolices.*—Intestinal juice, of three dogs and of three kittens was tested. In spite of the reaction of the juices being quite alkaline, they were completely inactive and no digestion occurred within 24 hours (Table II).

Effect of Bile on Scolices.—Bile from four sheep, four cattle and three kittens was tested and was found to have no digestive action on the scolices. A small number of scolices evaginated. Contraction of scolices was quite marked.

Experiments in Vivo.

These experiments were planned to study the behaviour of scolices in the digestive tracts of naturally susceptible and naturally immune animals to infestation with *E. granulosus*. Kittens, rats and rabbits were used in the experiments.

1. *Experiments on Kittens.*—Approximately 20,000 or more viable scolices of *E. granulosus* were fed together with some cuticular membrane from cysts to each of seven kittens. The kittens were killed at different time intervals, and their stomach, small intestines and caecum were carefully examined in order to observe the condition of the scolices in different parts of the digestive tract.

Kitten No. 1 was killed two hours after the infective feed. Its stomach was still full of scolices and membranes. The cuticular membrane of the

cyst was gelatinous and translucent. Scolices were perfectly intact, slightly contractile, still invaginated and showed no evidence of digestion. Some scolices had reached the duodenum, most of which were still invaginated but all of them were actively contractile. A small number of scolices were found in the jejenum and ileum which were hyperactive and fully evaginated. Feeding material had not yet reached the caecum, so that neither débris of cuticular membrane nor scolices were found in it.

Kitten No. 2 was killed five hours after the infective meal. Its stomach was completely empty. Between the rugae an occasional scolex was found which was inactive and invaginated. There was no evidence of digestion. In the small intestines many scolices were found, most of which were actively contractile and completely evaginated but none in the process of digestion. The caecum was full of shreds of cuticular membrane which apparently had not undergone much further digestion in the small intestine as they appeared translucent and gelatinous just as the ones seen in the stomach of kitten No. 1. There were innumerable scolices in the caecum which were actively contractile. Of these approximately 28% were evaginated, 10% in the process of digestion, and the rest were still invaginated. The material recovered from the caecum was kept in the incubator at 37°C. overnight, and the next morning all the scolices were found in an advanced stage of digestion.

Kitten No. 3 was killed twenty-four hours after the infective feed. The stomach was completely empty and no scolices were found between the rugae. In the duodenum and jejenum several hundred scolices were found which were all evaginated and actively contractile. In the ileum there were only a few evaginated, active scolices. The caecum still contained the remains of the cuticular membrane but the scolices were almost completely digested.

Kitten No. 4 died of diarrhoea seven days after the infective feed. No scolices were found in the stomach. Only fifty scolices were found in the washings and scrapings of the small intestines. These were actively contractile and were definitely growing as was evident from the larger size of the heads and elongated necks. No scolices were found in the caecum.

Kitten No. 5 died of diarrhoea eight days after the infective feed. No scolices were found in the stomach or caecum. In the small intestines only six growing scolices could be found.

Kitten No. 6 died twenty-one days after the infective feed. Careful search of the washings and scrapings of the small intestine revealed seventy-two growing scolices, most of which had already one definite segment added to the neck. Naturally nothing was found in the stomach and caecum.

Kitten No. 7 was killed 65 days after the infective feed. No scolices, mature or immature, were found in the intestines.

Experiments on Rats.—Four adult rats were fasted overnight and the the next morning at 9 a.m. they were fed hydatid cyst membranes full of scolices. Rats ate the cyst material readily but intermittently. They were killed at different time intervals and their intestinal tract was carefully searched for cyst material.

Rat No. 1 was autopsied 1–3 hours after the infective feed. The stomach was still full of shreds of cyst membranes which were crumpled and very slightly gelatinized. Upon microscopic examination numerous invaginated scolices were found, showing no visible signs of contraction nor any evidence of digestion. Here and there in the small intestines shreds of membranes were found. The scolices found in the small intestine were actively contracting except for a very few, some were fully evaginated, others still invaginated and still others showing slight evidence of digestion. The caecum was also full of membranes, now reduced into tiny particles. Many scolices were found in the caecum, some of which were evaginated and slightly contractile, while the majority, as yet, were invaginated, and still others were in the process of early digestion.

Rat No. 2 was autopsied 3–7 hours after the infective feed. At autopsy the stomach was found completely empty. Careful search revealed only a few invaginated scolices between the rugae. In the intestines there was very little débris of membranes and a rather small number of scolices. Of these the majority were actively contractile and evaginated, others invaginated and a few in a stage of digestion. The caecum, however, was full of cyst material. The membranes were in an advanced stage of digestion. Together with actively contracting evaginated scolices, there were others still invaginated and many others in different stages of digestion. Faeces from the rectum was also examined and was found to contain scolices in all stages of digestion together with many invaginated and evaginated scolices, some of which were still contracting. Newly passed faeces from the third rat showed also the same picture.

Rat No. 3 was autopsied 15–24 hours after the infective feed. The stomach was found completely empty, and no scolices were found in between the rugae. In the washings and scrapings of the intestine a few scolices were found in different stages of digestion. In the caecum and rectum there was no débris recognisable as remains of cyst material. Careful microscopic search revealed only a few partially digested scolices and a few others still undigested and invaginated.

Rat No. 4 was killed 19–25 hours after the infective feed. No remains of cyst material nor scolices could be detected in the stomach and in the small intestines. In the caecum the digestion was far advanced, and here also the remains of cyst membranes could no longer be recognised. However, careful microscopic examination showed very few scolices in process of digestion. In the faeces from the rectum there were a few scolices in the process of digestion.

Experiments on Rabbits.—Five young rabbits were fed large amounts of scolices and membranes from fertile hydatid cysts.

Rabbit No. 1 was killed two hours after the infective feed. Scolices and the membranes were found in a mass in the cardia not yet mixed with grass already in the stomach. Smears from the wall of the stomach showed numerous scolices which were still invaginated and showed no signs of contraction or digestion. The feed had not yet passed into the small intestine, therefore no scolices were found outside the stomach.

Rabbit No. 2 was killed five hours after the infective feed. Most of the feed was still in the stomach. Microscopic examination showed numerous inactive, invaginated scolices. There was no evidence of digestion. In the small intestines there was some débris of membranes. There were some scolices in an early stage of digestion and others slightly contractile. Only very few of the scolices were evaginated. There was no débris of membranes in the caecum.

Rabbit No. 3 was killed 9 hours after the infective feed. Some of the membranes were still in the stomach, broken into tiny shreds. In the stomach there were still a few invaginated scolices and a few others in a stage of digestion. The type of digestion was more like the digestion of scolices in the intestinal juices. In the small intestines there was some débris of membranes and very few scolices, in a late stage of digestion. No cyst material was detected in the caecum.

Rabbit No. 4 was killed 15 hours after the infective feed. In the stomach the remains of the cyst membrane were still visible, but reduced to tiny particles. There were no scolices to be found. In the small intestines a few scolices were in a late stage of digestion. No cyst material was detected in the caecum.

Rabbit No. 5 was killed 29 hours after the infective feed. No débris or cyst membranes, nor remains of scolices could be detected macroscopically or microscopically in the intestinal tract. The feed was completely digested.

Discussion.

The above experiments indicate that gastric juice of different animals that were studied was found to have practically no digestive power on the scolices of *E. granulosus*. Human gastric juice seems to have slight digestive power but this begins to be effective only after about eight hours. This being the case, even in man, gastric juice does not play an important rôle in the digestion of scolices, inasmuch as in any normal individual the stomach evacuates itself in a much shorter time. On the other hand, the intestinal juice of man, sheep, cattle, rabbits and rats seems to be quite capable of digesting scolices while that of dogs and cats is inactive. Duodenal juice of man was found to be highly active on scolices, as they were digested in less than eight hours. The intestinal juices of sheep and cattle seem to have a slower action. On comparing our *in vitro* and *in vivo* experiments we find that it is possible to infect cats and dogs, animals whose digestive juices do not attack the scolices, while our *in vitro* experiments on the juices of sheep, cattle and man show that the intestinal juices of these animals digest scolices, and it is known that all of these animals are naturally resistant to the tapeworm. Hence there is a close parallelism between the *in vitro* and *in vivo* experiments.

There is also a parallelism between the digestibility of scolices and cyst membranes. Hydatid cyst membranes are completely digested in the intestinal tract of rabbits, almost completely digested in rats and only slightly digested in that of kittens.

On considering the speed with which food passes through the alimentary tract of various animals one finds a wide variation. The process of digestion in the stomach and intestines of herbivorous animals is quite slow. Food remains in their stomachs for many hours and then passes very slowly through the small intestines and remains in the caecum for a long

period before it is excreted ; therefore, the digestive juices of these animals have a much longer time to act on the food. The intestinal juices of rabbits, sheep and cattle are capable of digesting scolices, and therefore these animals are naturally immune to infection with *E. granulosus*.

The speed of passage of food through the alimentary track of rats was found to be rapid. The infective feed had reached the caecum within less than three hours, the stomach and intestines being completely empty, whereas in the case of rabbits, fifteen hours after the feed, part of the food was still in the stomach. With such a rapid passage of food through the small intestine, scolices have little time in which to localize themselves in between the villi of the small intestine ; and moreover, they are readily digested by the intestinal juices of the rat. The finding of active undigested evaginated scolices in the faeces of the rats is due to the speed of intestinal movement. The movement of food through the intestinal tract of kittens is slower than that of the rats, besides, the pancreatic juice of kittens seem to possess no digestive action on scolices. The movement of food through the gastro-intestinal tract of man is more or less comparable to that of kittens in so far as time relationships are concerned.

An important observation made in connection with the above experiments is that the process of digestion begins with evaginated scolices, and as long as a scolex remains invaginated it either escapes digestion and is excreted in the faeces undigested, or it is digested slowly and often partially.

Observations on the evagination of scolices in neutral and alkaline media gave us the following additional information :—

(*a*) The time and rate of evagination varies with different batches of scolices taken from different animals.

(*b*) Scolices from a single cyst do not all evaginate at the same time or uniformly. Some evaginate readily, others slowly or not at all.

Evidently scolices ripen progressively rather than all at once. The over-ripe scolices evaginate readily, and therefore are subject to early digestion. The ripe scolices evaginate at the right time and in the right place in the digestive tract ; that is, in the second or third part of the duodenum or jejenum ; whereas unripe scolices either fail to evaginate altogether or evaginate late and are therefore either digested or pass out

intact. Such a condition is undoubtedly in the interest of the parasite, as its chances of infectivity is lengthened over a long period.

From previous experience in examining the intestines of over 500 dogs for *E. granulosus*, we have learned that these tapeworms have a narrow zone of attachment in the small intestine, confined to the second and third part of the duodenum and the jejenum. The ileum is practically always free of *E. granulosus*. Are scolices so specific in defining their exact site of attachment, or is it possible that the ones attached below in the ileum and caecum are sooner or later digested or eliminated? There is some experimental evidence in our data to support the latter contention. In the caeca of kitten No. 2 and 3, there was evidence of digestion of some of the scolices.

Natural infestation of cats with *E. granulosus* is still a disputed problem as it seems to be exceedingly rare. Cameron (1927) cites two cases of infestation with *E. oligarthus* in cats. Hosemann (1928) quotes Putzu who believes that in Sardinia cats as well as dogs are infested with *E. granulosus*. Dew (1928) refers to Wernicke and Barbagellos who have claimed infestation of cats under natural conditions. Hall (1919) reviewing the adult taenioid cestodes of dogs, cats and related carnivores in North America, lists the adult *E. granulosus* as having been recorded from *Felis catus-domestica*, and *F. concolor*. There are, moreover, a number of successful records of experimental infection of cats with *E. granulosus*. Hosemann and Schwartz (1928) refer to Leuckart and Peiper who succeeded in infecting cats experimentally once out of seven experiments. Dévé (1904) and Southwell (1927) report successful experimental infection of cats, whereas C. Ross (1925) and Wittenburg (1933) record their failures. The experiments reported in this paper add to the list of successful infections. However, in our past records there are three unsuccessful attempts to infect adult cats. It is to be noted that although we were successful in infecting kittens with *E. granulosus* by feeding huge doses of infective material, the degree of infestation in these animals was low in comparison to the size of the infective dose. Dogs with much smaller doses of scolices show a high degree of infestation. Although experimentally in this series we succeeded in infecting cats and this with difficulty, in none of the kittens did the scolices develop into mature tapeworms. The kittens got rid of the infestation gradually but completely. Consequently the fear expressed by Dévé and Southwell that cats may constitute a source of

contagion with hydatidosis for man, is no doubt exaggerated. It is to be noted that in Dévé's as well as in Southwell's experiments tapeworms recovered at autopsy were immature. Southwell, on two successive days fed a kitten hydatid cyst material which contained numerous scolices. He killed the cat after 68 days and found a very large number of immature specimens of *E. granulosus* in the lower portion of the ileum. He stated that in the experimentally infected fox the parasites were mature but not gravid in 27 days, whereas in the cat they were not even mature after 68 days. This much therefore becomes apparent, that cats have not yet been proven to constitute a problem in the epidemiology of hydatidosis.

The rarity of natural infestation with *E. granulosus* in cats is commonly known. Our unpublished data on immunization of dogs against *E. granulosus* show that even amongst such highly susceptible animals as dogs occasionally one encounters a dog which cannot be experimentally infected. Cats are undoubtedly abnormal hosts for *E. granulosus*. Though the scolices are not injured by the digestive juices they are prevented from undergoing normal development. An analogous observation was made by Scott (1928) who found that when larvae of *Ancylostoma caninum* were administered to the rat, an abnormal host, they were not all eliminated at once ; some lived for as long as twenty-one days, and although a few grew to maturity at a retarded rate, others failed to show any development whatever. The factor that inhibits or retards development in these animals does not seem to be merely the action of digestive juices.

In so far as *E. granulosus* is concerned host-parasite relationship falls into three categories :—

(*a*) Susceptible hosts, such as dogs, which permit a heavy infestation, normal development and reproduction to the parasite.

(*b*) Abnormal hosts, such as cats, which permit only a light infestation and inhibit or retard normal development.

(*c*) Resistant animals, such as rats, rabbits, man, sheep and cattle, which are specifically immune against *E. granulosus* in virtue of their digestive juices.

It has to be noted that natural immunity to the protozoal and bacterial infections as well as to helminthic infestations may be the result of the action of digestive juices of the host in which the infective agent passes through the digestive tract at some time or another in its life cycle.

Summary.

Experiments *in vivo* and *in vitro* are reported on the action of digestive juices of various animals on the scolices of *E. granulosus*. In *in vitro* studies, scolices of *E. granulosus* were placed in the digestive juices of different animals, incubated at 37°C., and the digestive action of the fluids was studied by examining portions of the material under the microscope. *In vivo* experiments were carried out on kittens, rats and rabbits. These animals were fed large quantities of scolices of hydatid cyst membranes and they were killed at definite time intervals and their intestinal tract was carefully examined for scolices.

Gastric juice of rats, dogs, cats, sheep and cattle did not digest scolices. The action of the gastric juice of rabbits begins late and proceeds slowly. Human gastric juice causes incomplete digestion and acts only on the evaginated scolices.

The intestinal juices of man, rats, rabbits, sheep and cattle are able to digest scolices completely, whereas the intestinal juice of dogs and cats is inactive. In spite of the fact that cat intestinal juice is inactive, kittens are found to be slightly susceptible. Since they suffer only relatively light infestation and the rate of development is retarded, we would classify the cat as an " abnormal " host to *E. granulosus*.

Time of evagination of scolices from a single cyst or from cysts from different animals is variable. Some scolices evaginate readily, others more slowly and still others fail to evaginate completely.

Conclusion.

Natural immunity or susceptibility to infestation with dog tapeworm *E. granulosus* is found to be dependent primarily on the action of the digestive juices, particularly the intestinal juice. Those animals which have an intestinal juice capable of digesting scolices are on that account immune to infestation with *E. granulosus* and those which have an inactive intestinal juice are either susceptible, or abnormal hosts permitting partial development.

Hence it is suggested that digestive juices may play an important rôle in determining immunity or susceptibility to parasites that have to pass at any period in their life cycle through the alimentary tract of their vertebrate or invertebrate hosts.

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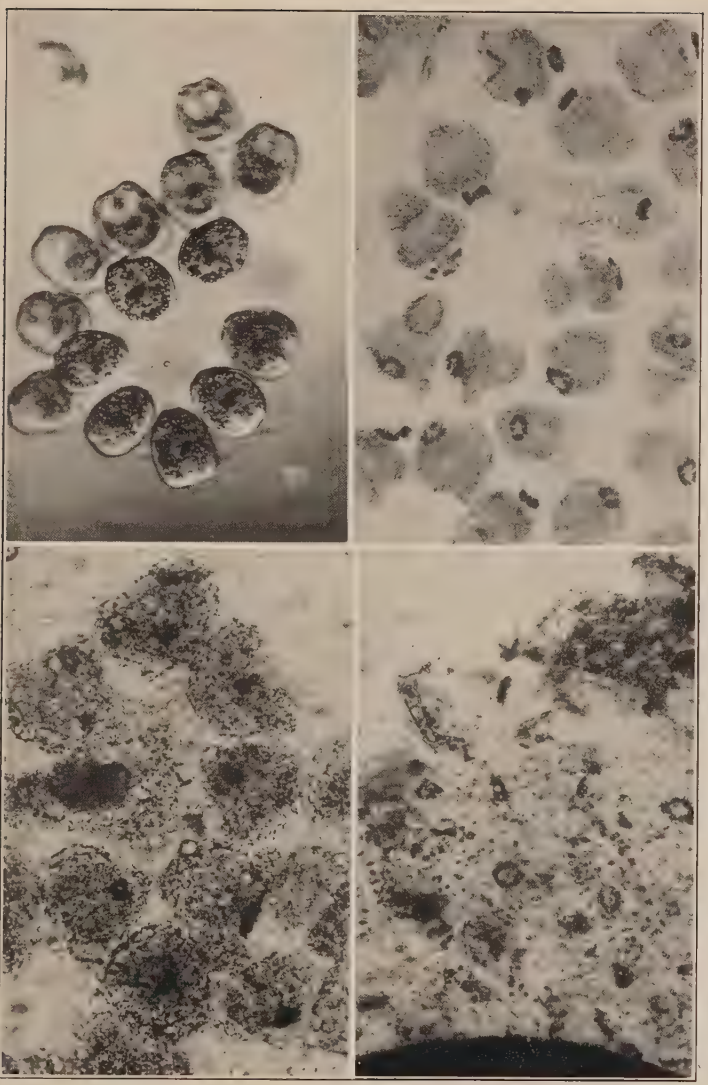

Fig. 1. Normal appearance of scolices.

,, 2. Appearance of scolices after eight hours of digestion in artificial gastric juice. Scolices are not completely digested.

,, 3. Appearance of scolices after twenty hours of digestion in human gastric juice. Scolices are not completely digested.

,, 4. Appearance of scolices after three hours of digestion in human duodenal juice (Bile B). Scolices are almost completely digested.

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Journal of Helminthology, Vol. XIV, *No.* 1, *March*, 1936, *pp*, 41–60.

Investigations on the Nematode Disease of Potatoes caused by *Anguillulina dipsaci*.

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Introduction.

It has been known for a number of years that potatoes, besides many other cultivated plants and weeds, are subject to attack from the eelworm, *Anguillulina dipsaci*.

Kühn gave the first account of the disease produced in the potato in 1888 under the name *Wurmfaüle*. Four years later Ritzema Bos described it in greater detail and carried out infection experiments. More recently it has been dealt with briefly by Marcinowski in 1909 and at considerable length by Quanjer in 1927.

In Britain the first record of *A. dipsaci* on potatoes is that by Theobald who reported it from " a locality near London and another from Kent " in 1909. No subsequent attacks in this country on potatoes seem to have been recorded until 1923 when Goodey published an account of its occurrence in Lincolnshire and added a short résumé of the work of the earlier investigators. A detailed description of the symptoms of attack was also given by Goodey in this publication as well as certain suggestions with regard to control of the eelworm under farming conditions. The measures recommended for control were preventative in character and included (*a*) planting of only sound undiseased seed potatoes, (*b*) careful lifting of tubers to ensure that no diseased ones are left in the soil to perpetuate the malady, (*c*) steaming of attacked tubers prior to being fed to farm animals and (*d*) the use for seed purposes of those varieties which seemed least affected by the disease. In connection with the latter suggestion it was indicated, however, that " valuable information would probably be obtained if a large range of different varieties could be tested on land which has carried the disease so as to ascertain which are resistant and which susceptible." In 1928, an opportunity to carry out such a test presented itself to the present writer whilst acting as an Advisory Zoologist on the

staff of the Agricultural Experimental Station, Kirton, Boston, Lincolnshire. In addition to this test of susceptibility of varieties of potatoes to attack from the parasite, comparative control trials of soil treatment by certain chemical substances on a commercial scale were also conducted on the same land.

The present paper embodies the results obtained from these two and other lines of investigation as well as the general field observations made of infested areas. Delay has been inevitable in the preparation of this publication, partly because the writer was appointed early in 1929 to a post in a part of the country remote from where the trials were started and partly because it was considered advisible to obtain further evidence of the value of the results of some of the 1928 experiments. Although no other opportunity has presented itself to the writer for repetition of such field trials, there is now, however, some considerable data on the subject of varietal susceptibility of potatoes to attack from the eelworm through the recent publications by Goodey (1929, 1935).

Field Experiments on Control.

Soil Treatment Trials.—In the autumn of 1927 an area of 1¼ acres was marked off on an arable field at Gedney Dyke in Lincolnshire to be devoted to a series of experimental plots with a view of testing the effect of various chemical substances on the incidence of the disease produced by *A. dipsaci* in potatoes. The field was uniform as regards previous cropping, cultivation and manuring. The last crop which was potatoes had been almost a complete failure due to an attack from this eelworm. The variety Majestic had been planted and yielded over 13 tons to the acre. The bulk of the crop had been stored for the winter in a pit or clamp on the field and some three months later the farmer called the writer's attention to the serious diseased state of the tubers. There could be no doubt that *A. dipsaci* was the primary cause of the disease and that secondary invaders of various kinds, both animal and vegetable, were at work. So advanced and widespread was the rotting condition of the potatoes throughout the clamp that only a small proportion of the stock could be saved and this was unsaleable for human consumption.

The soil might be described as a sandy loam, typical of soil commonly found in the south-eastern districts of Lincolnshire and very suitable for growing potatoes. The mechanical analysis was as follows (per cent.) :—

Moisture	1·41	Fine sand	69·87
Loss on ignition ...	4·72	Silt	11·75
Carbonates (CO_2) ...	1·21	Fine silt	2·50
Coarse sand	0·17	Clay	6·75
Loss by solution ...	1·62		

The following is a chemical analysis of the soil from this field, which can be regarded as slightly poorer, particularly in nitrogen content, than that of the average for the lighter types of soil in these districts (per cent.) :—

Nitrogen	0·167	Available Potash ...	0·022
Available phosphates ...	0·061	Calcium carbonate ...	2·43
Lime requirement ...	Nil.		

The experimental area was divided up into 24 small plots each $\frac{1}{20}$ of an acre in size and measuring 30 yards long by $8\frac{1}{3}$ yards wide. The following diagram shows the arrangement of the plots together with the nature and the amount applied of the different dressings to the respective plots.

Plan of Experiment.

Plot 10b Calcium cyanamide at 6 cwt.*	Plot 7b Creosote salts at 10 cwt.	Plot 9b Muriate of potash at 6 cwt.
Plot 8b Sulphate of potash at 6 cwt.	Plot 1d Control	Plot 2b Carbon disulphide at 30 gal.
Plot 5b Sodium chloride at 10 cwt.	Plot 4b Bleaching Powder at 6 cwt.	Plot 3b Calcium cyanide at 3 cwt.
Plot 6b Naphthalene at 5 cwt.	Plot 11b Ground quicklime at 30 cwt.	Plot 1c Control
Plot 1b Control	Plot 9a Muriate of potash at 6 cwt.	Plot 10a Calcium cyanamide at 6 cwt.
Plot 7a Creosote salts at 10 cwt.	Plot 2a Carbon disulphide at 30 gal.	Plot 8a Sulphate of potash at 6 cwt.
Plot 11a. Ground quicklime at 30 cwt.	Plot 1a Control	Plot 4a Bleaching powder at 6 cwt.
Plot 3a Calcium cyanide at 3 cwt.	Plot 6a Naphthalene at 5 cwt.	Plot 5a Sodium chloride at 10 cwt.

* The rates given for the various dressings are per acre in each case.

All the various chemical substances were applied four weeks before planting the potatoes. The calcium cyanide, drained creosote salts and whizzed naphthalene were broadcast and ploughed in immediately after the application to a depth of about 6 in. The liquid carbon disulphide was applied with a pneumatic hand sprayer which distributed the chemical in a fine, misty spray over the bottom of the furrow at a uniform rate in front of the plough and the fluid was thus immediately covered in. The remaining substances were evenly spread and worked well into the soil by means of a cultivator. All the plots were then given a double harrowing, followed by rolling with a Cambridge roller, in order to impregnate the soil thoroughly with the chemicals and to avoid as far as possible the escape of their vapours.

The whole experimental area was planted on 19th April, 1928, and the conditions and practices usual in the district for planting potatoes were observed. The variety selected was Majestic, being Scotch seed once-grown at the Kirton Experimental Station.

The plants on all plots made satisfactory growth. An exception must be noted in the case of the bleaching powder treated plots (Plots 4a, 4b). On these plots the foliage showed, at least in the early stages, a distinct yellowing accompanied by a definitely slower rate of growth, as if some retarding agent was at work. It was also evident early in the season that, whatever their ultimate effect might be as regards control of the disease, the drained creosote salts, whizzed naphthalene and carbon disulphide, certainly exerted a slight stimulating influence on growth and vigour of the plants. This beneficial effect was maintained for several weeks but eventually the plots became indistinguishable from the remainder.

The entire crop of all plots was lifted in the latter part of October. In order to get an accurate determination of the yield and the effect produced on the incidence of the disease under the various treatments, the produce of each plot was lifted separately by hand and every tuber carefully examined for the presence of disease or any sign of damage. Those tubers showing any of the symptoms associated with an attack by the parasite were set apart from the healthy ones. All the doubtful cases of attack were taken to the laboratory at the Kirton Experimental Station where at a later date a small portion of the suspected tissues was examined and the presence or absence of the eelworm established.

TABLE I.

Treatment	Index of Plot	Total Wt. of entire crop	Infected Tubers		
			Total Weight	Per-centage	Average percentage
		cwt. lb.	cwt. lb.		
Untreated (control)	1a	11 100	7 29	61	
	1b	12 22	6 79	55	
	1c	12 66	7 34	58	
	1d	11 30	7 24	64	59·5
Carbon disulphide ...	2a	12 72	5 77	45	
	2b	12 2	5 32	44	44·5
Calcium cyanide ...	3a	11 110	5 57	46	
	3b	10 74	4 53	42	44·0
Bleaching powder ...	4a	10 28	6 28	61	
	4b	11 2	6 7	55	58·0
Sodium chloride ...	5a	11 48	7 48	65	
	5b	12 62	7 31	58	61·5
Naphthalene ...	6a	11 52	7 25	63	
	6b	12 3	6 69	55	59·0
Creosote salts ...	7a	11 60	6 64	57	
	7b	11 58	5 85	50	53·5
Sulphate of potash	8a	12 90	6 88	53	
	8b	11 75	7 13	61	57·0
Muriate of potash ...	9a	12 35	6 73	54	
	9b	12 78	7 55	59	56·5
Calcium cyanamide	10a	12 56	7 14	57	
	10b	11 90	7 49	63	60·0
Ground quicklime ...	11a	11 85	7 6	60	
	11b	12 12	7 84	64	62·0

Having recorded the total yield of the whole crop from each plot and determined the weight of the tubers affected by *A. dipsaci* it was a simple matter to estimate the percentage infection for each plot. The results are tabulated on Table I where it can be seen that the degree of infestation of the parasite was of a fairly high and uniform order throughout the whole experimental area. When the figures for the average percentage infection are considered in relation to the various chemical dressings, which are shown in the final column of Table I, it is evident that none of the soil treatments employed checked or in any way rendered the tubers

less susceptible to an attack by the eelworm except perhaps in the case of carbon disulphide and calcium cyanide. The apparent control given by the latter two substances is, at any rate, exceedingly small and cannot be be regarded as significant, at least, from an economical standpoint.

Variety Trials. Arrangements were also made in the autumn of 1927 for a variety trial to test the susceptibility of some of the principal varieties of potatoes in commercial cultivation to *A. dipsaci.* The varieties chosen included Sharp's Express, Eclipse, Great Scot, British Queen, Arran Chief, King Edward, Field Marshal and Kerr's Pink, as well as Majestic from two different sources. Majestic A was, as in the case of the other varieties, of Scotch origin and once grown in Lincolnshire on land known to be free from infection. Prior to planting in 1928, the seed of all varieties was also carefully examined and the absence of the parasites established. Majestic B, on the other hand, though of a similar origin, had been grown in 1927 on infested land, and formed part of a stock actually on sale in South Lincolnshire in the spring of 1928 for seed purposes. On critical examination it was found that approximately 32 per cent. of the tubers were infected but only to a slight degree, the skin being in most instances neither cracked nor badly shrunken. It was also apparent that the true character of the disease in his stock of seed potatoes was not known to the farmer concerned and that the discolouration or mottling of the skin in small patches in the case of the affected tubers had been genuinely regarded by him as an indication of a fungal attack due to "blight" *Phytopthora infestans.*

Two strips of land were selected for these susceptibility trials, one on each side of the experimental area on which the various soil treatments were tested. Each strip was separated from this experimental area by a distance of four yards and extended the whole length of the field. One row of each variety was planted on the 19th April 1928 on each strip parallel to the long axis, the rows being 240 yards long and 30 in. apart.

All the plants, irrespective of variety, made excellent growth throughout the season, and there was an entire absence of symptoms from the foliage that would lead one to suspect the presence of the disease except in the case of Majestic B. The haulms of the plants produced on both the rows planted with Majestic B were very irregular in size and a large proportion of them rather stunted in growth when compared with those of Majestic A

or any of the other varieties. The leaves of a great many of these plants were also somewhat mottled-green in colour and presented a curled and wrinkled appearance.

The crop was lifted in the second week in November. At the time of lifting the entire produce of each plot was separately weighed and examined for the presence of the disease. The results are set out in Table II.

TABLE II.

Variety	Index of Plot	Total Wt. of entire crop	Infected Tubers		
			Total Weight	Per-centage	Average percentage
		cwt. lb.	cwt. lb.		
Sharp's Express ...	1a	8 110	4 75	52	
	1b	10 19	5 89	57	54·5
Eclipse	2a	11 93	8 31	70	
	2b	12 88	7 104	62	66·0
Great Scot	3a	14 30	7 63	53	
	3b	13 77	8 9	59	56·0
British Queen ...	4a	13 44	7 56	56	
	4b	12 67	7 63	60	58·0
Majestic A	5a	9 31	5 53	59	
	5b	9 87	5 108	61	60·0
Majestic B	6a	10 4	8 71	86	
	6b	9 63	7 94	82	84·0
Arran Chief ...	7a	13 32	7 64	57	
	7b	13 8	8 41	64	60·5
King Edward ...	8a	12 100	4 72	36	
	8b	13 17	5 44	41	38·5
Field Marshal ...	9a	16 69	10 34	62	
	9b	17 43	10 29	59	60·5
Kerr's Pink ...	10a	11 104	6 103	58	
	10b	12 82	6 55	51	54·5

The figures indicate that the infection was present on every plot and that all the varieties tested are susceptible to attack by *A. dipsaci*. When the figures for the average percentage infestation, which are shown in the final column are considered in relation to the separate varieties, it is apparent that different kinds of potatoes vary in the degree to which they are liable to infection but the differences are in general rather small. It would

appear from these trials that the variety King Edward is decidedly more resistant to attack then any of the other varieties which had been included in these tests. All these other varieties seemed to be subject to a very heavy infection of approximately the same order throughout except that Eclipse suffered more than the rest. It is obvious, however, that definite conclusions cannot be drawn as to susceptibility of different varieties of potato to infection from the results of one year, but only from those obtained over a succession of seasons and under diverse soil conditions.

It will also be seen from the figures of average percentage infection of tubers that considerable difference in the degree of infestation is shown between Majestic A and Majestic B which were grown from non-infected and infected stock of seed potatoes, respectively. It is realised that this increase of 24 per cent. in the extent of infection in the case of Majestic B may be fairly laid to the charge of planting seed that had been saved from an infected crop. Consequently, this result would seem to provide definite indication that the disease is spread from place to place by means of affected tubers getting into stocks of seed potatoes as had been generally suspected by earlier workers on *A. dipsaci*.

Influence of Time of Lifting of Crop and Storage on Degree of Infestation.

Previous field observations of infested areas in Lincolnshire had indicated that outbreaks of *A. dipsaci* in potatoes only assume an epidemic form under certain conditions. The most serious financial losses due to this nematode are usually found in districts where affected crops are not lifted until late in the season and in particular when the tubers of an infected crop are kept in storage for a considerable time. Acting on these circumstantial indications, a preliminary experiment was designed in 1927 to test (*a*) the influence of time of lifting of tubers on the degree of infestation and (*b*) the effect of storage on the keeping quality of tubers from an infected crop.

For this experiment, twelve rows of potatoes of the variety Majestic were planted in the third week in April alongside the area devoted to the trials already described. Each row extended the whole length of the field, being 240 yards long and 30 inches wide and occupied therefore an area of $\frac{1}{24}$ of an acre. The seed was of Scotch origin, being once grown in South Lincolnshire and free from infection by *A. dipsaci*. As in the other

trials in this field the plants made a vigorous growth and no evidence of an attack by " blight " (*P. infestans*) was noticed at any time either on the foliage or on the tubers.

For the purpose of the tests under consideration the experimental area was divided into 6 plots of two rows each and the crop lifted at different dates :—

(*a*) Plots 1a and 1b on 15th August, 1928.
(*b*) Plots 2a and 2b on 28th August, 1928.
(*c*) Plots 3a and 3b on 30th October, 1928.

The produce of each plot was separately weighed and examined for the presence of the disease. *In contrast to the method adopted in the other trials, the examination in the present instance was carried out not by the writer himself but by potato pickers under the supervision of the farmer on whose land these tests were conducted. The examination for diseased tubers in this experiment was therefore identical with that normally employed in practice in South Lincolnshire.* The tabulated results are shown on Table III, where it will be seen that the time of the year when the potato crops are lifted has an important bearing on the degree of infestation by *A. dipsaci*. It would seem from these results that, if lifting of the crop is carried out not later than the middle of August, the loss from infection by this eelworm, at least in South Lincolnshire, could be reduced to a minimum. It must not be inferred that this loss can always be avoided on infested land, even by lifting the crop by mid-August, as three instances have been observed by the writer of serious damage in early July and before the tubers were of saleable size. It was discovered in one of these cases, however, that seed saved from an affected crop had been planted in a field which was already very heavily infested, and it is possible that the combination of these circumstances may account for this rather unusual occurrence ; in the other two instances no such explanation was found. The various field observations made of infested areas also indicate that the exact date when potato crops should be lifted to avoid serious loss from this parasite varies to some extent with different varieties and even in the same kind in another season.

The disparity of 24 per cent. between the average percentage infection figures for Majestic A on Table II (Plots 5a, 5b) and those for the same variety on Table III (Plots 3a, 3b) is attributable to the fact that the tubers were less carefully scrutinised for the presence of the disease when

the examination was not carried out by the writer himself. It is found that lightly affected tubers are not easily recognised and are, in consequence, passed over during digging operations under ordinary farm practice.

The potatoes on Plots 3a and 3b after removal of the diseased ones were stored in a clamp on the field for a period of three months. An examination at the end of this period revealed that serious rotting had developed in the meantime within the clamp and that only 18 per cent. of the original weight of tubers stored could be utilized for human consumption.

TABLE III.

Date of lifting of Crop	Index of Plot	Total Wt. of entire crop	Infected Tubers		
			Total Weight	Per-centage	Average percentage
		cwt. lb.	cwt. lb.		
14th August, 1928	1a	13 64	46	3	
	1b	14 82	33	2	2·5
28th September, 1928	2a	19 84	5 104	30	
	2b	18 17	4 60	25	27·5
30th October, 1928	3a	19 67	6 74	34	
	3b	20 64	7 92	38	36·0

Biological Strains.

Considerable significance is attached to the question of whether the strain of *A. dipsaci* parasitic on the potato is capable of attacking other plant species of economic importance as on it depends the degree of safety with which possible alternate hosts might follow a crop previously attacked by the nematode.

While little experimental data exist concerning the degree of specialisation of this race to the potato, field observations certainly indicate the existence of at least a very marked rigidity as regards the inability to cause injury to another host plant. This is well exemplified by the following examples.

In certain districts in Lincolnshire, potatoes and oats are the two small holding crops and have been alternated on the same land for many years. No case of attack on the oats was noted by the writer in the course of the extensive observations made in 1927 and 1928, though frequently the potato crops were very heavily infested.

Similar cropping is also practised in many localities in Warwickshire and Monmouthshire where during recent years oats have become liable to severe infection by *A. dipsaci*. No sign of attack on the potato has so far been discovered in these areas even when grown on land which has ceased any longer to produce economical crops of oats owing to the depredations of the eelworm.

In the bulb growing districts of Lincolnshire, it is a common practice to grow at regular intervals crops of potatoes partly with the object of resting the land from bulbs and partly for cleaning purposes. A careful examination was made in 1927 and 1928 of all the potato crops in these districts and in particular those which were being grown on land known to harbour heavy infection of the Narcissus strain of *A. dipsaci*. In no instance did tubers show any indications of attack from the parasite.

On many of the farms in South Lincolnshire that were included in the field survey work on the incidence of the potato-strain, the cropping consisted of a three course rotation namely potatoes, cereals and clover ley (one year). Although the potato crops on these farms were found suffering from injury inflicted by this nematode yet careful scrutiny of both the clover and cereal crops failed to reveal any signs of attack.

" Clover Sickness " due to *A. dipsaci* is a disease of long-standing on a large number of farms in Shropshire and Staffordshire. The sum of the damage caused on many of these farms has become so great that clover can no longer be grown as a profitable crop in their usual rotations. Despite a careful study of likely alternate host plants to this strain in these two counties during 1929–34, in no case were any indications of attack noted on the potato or on any other non-leguminous plant. In fact, the potato is unknown so far as a host in these areas to this species.

It is also noteworthy that a very wide range of both agricultural and horticultural crops grown on land heavily infested with the potato race of *A. dipsaci* were examined for damage by this strain during the field investigations carried out during 1927 and 1928. No crop other than the potato was found, however, subject to injurious effects from this eelworm.

Consideration of the foregoing data which are based on extensive field observations over the past nine years and in several counties, seem to provide further evidence, if this be needed, in favour of the acceptance of the theory that several biological strains of *A. dipsaci* occur in Great Britain. The evidence presented points also to the conclusion that the

potato race is so highly specialised to this particular plant, at least in South Lincolnshire, that any other agricultural crop could be selected in planning suitable rotations whereby an effective control of the parasite can be secured.

Crop Rotation.

Slogteren (1920) and Goodey (1931) have shown in the case of the narcissus strain of *A. dipsaci* that the parasites cannot live more than twelve months in moist soil and in the absence of a suitable host plant. With a view of determining whether this discovery applies equally well to the potato race of this species, the writer conducted an experiment in which six 12-inch earthenware flower pots were used. The soil utilised, the same in the six pots, was already heavily infested with the potato race of *A. dipsaci*. In April 1932 a single tuber of the variety Majestic was planted in each pot. The pots were then plunged in a bed of soil in an open air enclosure and the plants were thus grown under climatic conditions comparable with those in the field. Care was exercised in lifting the crop in the autumn to ensure that all the tubers were removed from the soil in each pot. Most of these tubers were found severely attacked. In April 1933 a single non-infected tuber of the variety Majestic was again planted in three of the pots. As in previous year the weeds in all the pots were carefully kept down throughout the season. The crop in the three pots was lifted after all the haulms had completely died down. As expected, the majority of the tubers showed the presence of disease and the accompanying parasite. In early May 1934, all the pots were planted, a non-infected tuber of the variety Majestic in each pot. The produce of each pot was carefully removed from the soil and examined as in previous years for symptoms of infection. This examination revealed that all the tubers obtained from the three plots which had carried no crop in 1933 were free of disease whilst most of those from the other pots showed a moderate infestation. It is also noteworthy that there was a decidedly progressive loss of infection, judging from the amount of damage to the tubers, in the course of the three years even in the pots which had been planted with potatoes each season. This result may be explained that with the careful lifting of the crop each season the main source of infection was also gradually removed. Such explanation accords with the observations of Goodey (1935) who indicates that where potatoes are grown on

the same land year after year the degree of infestation with *A. dipsaci* declines rather than increases, at least under experimental conditions, when care is exercised in removing all the tubers from the soil.

Although a single trial is insufficient evidence on which to base assumption that the potato race of this nematode is unable to set up an infection in healthy tubers after an interval of eighteen months, these results, taken in conjunction with the observations of Slogteren and Goodey (1920, 1931) on the narcissus strain, appear to be of some considerable significance. It must not be assumed, however, that provided an infected field is rested from potatoes for one year complete control is assured. In fact it is found in practice that much longer intervals are essential between successive crops of potatoes before complete eradication of the parasite can be secured. Naturally it would be unwise to draw any definite conclusions as to the reason for these contradictory results until further investigations into the persistence of the parasite in moist soil and in the absence of its normal host plant have been conducted. At the same time it seems fairly safe to conclude from the general field observations made of infested areas that it is in any case exceedingly doubtful whether land could be cleared of infection on all farms merely by the omission of the potato crop for one year only, since often under the best farming conditions a comparatively high proportion of the tubers are overlooked and left in the soil when the crops are being lifted. Many of such tubers which are left in the soil grow and produce plants the subsequent season and thus constitute a residual source of infection in the soil. This method of tiding over the intervening period between the potato crops must not be regarded however, as applicable in all instances as attacks of a severe nature have been noticed by the writer on farms where cultivation and weeding operations are so thoroughly executed that exceedingly few, if any, of the tubers accidentally left in the soil ever succeed in becoming established in the alternate crop. Further, such an explanation would hardly be feasible in the case of infestations noted on farms where potato crops had been grown but once in three years on the same land. It seems scarcely reasonable to suggest that the tubers planted on all these farms were infected since in some instances it was discovered that seed potatoes obtained from a similar source had not given rise to the disease when planted on other farms in the same district. On the whole it seems more reasonable to suggest that the persistent failure of short rotations to affect control on

certain farms may be associated with the presence of a weed which provides suitable food for the nematode in the interval between the potato crops. Assuming such association, it would then become difficult to account for the fact that omission of potatoes for four years from the rotation of crops generally ensures successful control of the parasite whilst a shorter rotation is seldom efficient in this respect. This fact cannot be regarded as sufficient evidence in itself for excluding the possibility of weeds forming reservoirs of infestation for the parasite in the absence of the potato plant, since it is plausible that with the repeated destruction of weeds over a number of years the main source of infection is eventually removed. The failure of all attempts in the past to ascertain the means whereby the parasite is enabled to bridge the years intervening between the potato crops, and the serious financial losses caused by the nematode in many localities, greatly emphasize the immediate need for further bionomical researches which should be directed in particular towards the elucidation of the problem of control.

Pot Infection Experiments.

In order to obtain more exact data on some of the problems that await elucidation particularly those connected with the dissemination of the parasite, four series of pot experiments were set up by the writer at the Harper Adams Agricultural College in 1930. The soil used in these experiments was from a field in South Lincolnshire known to carry a heavy infection, at least the potato crop grown in it in 1929 had been virtually a complete failure due to the depredations of the nematode. This soil was divided into four different bulks :—

1. Soil infected by *A. dipsaci*, untreated.
2. Soil infected by *A. dipsaci*, steam sterilised.
3. Soil infected by *A. dipsaci*, steam sterilised and reinfected with the parasite by the addition to the soil of diseased tuber material.
4. Soil infected by *A. dipsaci*, steam sterilised.

The soil in Nos. 2 to 4 was partially sterilised about the last week of January by means of steam under pressure in an autoclave so as to destroy all the eelworms present. Eight 12-inch earthenware flower pots were used for each bulk of soil Nos. 2 to 4, and ten for No. 1. A dressing of artificial manure consisting of 3 parts sulphate of ammonia, 4 parts superphosphate and 2 parts sulphate of potash was added to the soil in

all pots at the rate of 12 cwt. to the statute acre. All the pots were then placed in groups, according to their series, in an open air wire-covered enclosure and sunk in the soil to within two inches from the rim.

A single well sprouted tuber of the variety Majestic was planted in each pot on April 15th. The tubers chosen were of approximately equal size, being Scotch in origin and once grown in Lincolnshire. Care was exercised to ensure that only sound, unattacked tubers were used in Series 1 to 3. Those selected for Series 4, on the other hand, exhibited well marked diseased symptoms characteristic of attack by *A. dipsaci*. In each case the presence of the eelworms within the affected pots was also established.

The periodical examinations which were made throughout the season revealed considerable differences in the appearance and condition of the plants in the various series. The plants in Series 2 appeared above ground some 4 to 7 days in advance of the majority of those in the other three Series. This advancement in appearance of foliage in Series 2 was also accompanied by a quicker rate of growth throughout the earlier part of the season as well as more uniformity with regard to the amount of haulms produced by individual plants. The slow growth and the irregularity in size of the haulms was most pronounced in Series 3. Of the remaining Series 1 and 4, the latter showed the least improvement over Series 3 in these respects, particularly with regard to the variation between individual plants in the extent of growth made. As the season progressed these differences gradually became less apparent, and by the end of July were no longer very striking.

A careful examination of the haulms failed to show in any of the four Series definite distortion of the stems or presence of *A. dipsaci* in yellowish brown spots here and there in the leaves such as were observed by Ritzema-Bos in two plants which he succeeded to grow from affected tubers. Slight curling and wrinkling of the leaves was evident, however, in some plants in Series 1 and 3 and in particular in Series 4. The foliage, on the whole, in these three Series was also of a paler green colour than in Series 2 and the lateral shoots exhibited a tendency to droop downwards.

The haulms of many plants in Series 1, 3 and 4 started to die off in the earlier part of September. At this time the haulms of all plants in Series 2 were green and luxuriantly healthy and remained in this condition until October 2nd to 12th.

The plants were lifted after all their aerial parts had completely died down, and the crop from each pot was carefully examined for the presence of the disease or any sign of damage associated with attacks of *A. dipsaci*. All the tubers in Series 2 were found entirely free of infection. The majority of those in Series 1, 3 and 4, on the other hand, showed, irrespective of its Series, well marked symptoms of the disease in several stages of development, some being only slightly and others more severely affected. The degree of infestation varied in the different series as judged by the percentage of tubers injured by the parasite. The average percentage infection figures obtained in this way for Series 1, 3 and 4 were 62, 88 and 66 respectively.

The practical import of the information as can be deduced from a consideration of the results of these pot experiments is perhaps, at this stage, not very conclusive as to whether the presence of the disease is sufficiently manifested in the aerial regions of the potato plant for its early detection in the growing crop. It is realised that considerable economic significance is attached to a positive proof of the existence of such manifestation as it would then become possible for the potato grower to adopt defensive measures.

Definite experimental evidence has been obtained, however, in support of the widely accepted supposition that affected seed potatoes are able to set up infections in non-infected soil. When it is also remembered that lightly affected tubers escape detection under ordinary farming practice and are distributed as seed potatoes, as already shown in this paper, it becomes evident that new centres of infection are constantly being established which, with frequent cropping with potatoes, have every opportunity of spreading and rendering the land valueless for potato-growing not only within a limited district but also in widely separated regions.

Finally, it can be concluded from these experimental results that the nematode can spread to fresh sites through contamination of the soil with diseased tuber material other than by the use of infected seed potatoes. There is little doubt, judging from observations made on affected farms, that small foci of infection become established in this way at least within a limited area owing to the practice of depositing infected tubers on the manure heap or in the fields for food to farm animals. Fresh infections brought about in such a manner though usually at first involving but few small isolated patches in a field are found to spread over large areas in a

comparatively short time. Thus on one small-holding in Lincolnshire, including only four arable fields and where new stock of seed potatoes was used each season, an infestation which was first noticed in a small patch in one field in 1923 had by 1929 spread over the greater part of the field and even into the neighbouring three fields. In the light of our knowledge of other plant parasitic nematodes (Goodey, 1933), it is highly probable that additional factors also become involved in the rapid local dissemination from small infested areas over ever-increasing regions. Amongst the most important of these factors may be mentioned the active wandering of the infective pre-adult larvae in the ground and the transport of infected soil by various mechanical agencies such as cultivation, surface draining and earth adhering to farm implements, the boots of workmen and the feet of animals.

Recommendations on Control.

From the investigations here described and from those reported by various investigators on the other strains of *A. dipsaci*, it is evident that no chemical treatment of the soil for the extermination of the parasite can be recommended as sufficiently practical to merit adoption under farming conditions. Fortunately, however, it is found that elimination of infections from land can be effected by the introduction of well-planned crop rotations. The evidence presented in this paper points to the conclusion that any of the common agricultural or horticultural crops might be included in such rotations without risk of infection because the nematode seems to be so highly specialised to the potato plant as to form a distinct biological strain capable of attacking under ordinary conditions a single host species only. The exact length of time that should intervene between one potato crop and the next in the rotation cannot be definitely stated, but, judging from the general field observations already described, an interval of three years may often be sufficient, though instances are known of satisfactory crops after a rest for two years. In adopting this means of control, special precautions are essential, at least in the case of rotations of very short duration, in the lifting of affected crops to ensure that no diseased tubers are left in the ground for the perpetuation of the parasite. Further, in view of the fact that Quanjer (1927) claims to have traced an outbreak on potatoes in Holland to the parasite occurring on certain wild hosts, namely, *Cardamine pratense*, *Trifolium repens* and *Ranunculus*

repens, it appears reasonable to suggest that the land should also be kept as free from weeds as possible during the interval between the successive crops of potatoes.

It has been shown in the course of the present investigations that slightly affected tubers do find their way into stocks of seed potatoes and that such tubers can be the occasion of the onset of the disease in non-infected soil. There is good evidence that the true character of the disease produced by this nematode is not generally known amongst potato growers, resulting in its confusion with the fungal attack due to "blight"—*Phytophthora infestans*. These facts point to the desirability of exercising great care in the selection of perfectly sound undiseased tubers for seed purposes and of thorough examination of any doubtful samples of seed potatoes by qualified persons.

The efficiency of measures to prevent the dispersal of any outbreak of disease is not only dependent on the use of non-infected seed potatoes but also on adequate supervision to ensure that no affected tubers are thrown on to the manure heap or gain access by any other means to non-infested areas. In addition all the potatoes considered unsaleable for human food should be steamed or otherwise suitably cooked prior to being fed to live stock on farms as no work has so far been conducted on the ability of the nematode to survive passage through the alimentary tract of warm-blooded animals. Meanwhile the precautionary measure against further dissemination of the disease in this country by the adoption of restriction in the sale of seed potatoes from areas known to harbour the parasite might well be considered.

It would seem from the results of the field susceptibility trials when taken in conjunction with those reported by Goodey (1929, 1935) that all the principal varieties of potatoes in commercial cultivation, whether earlies, second-earlies or main crops, are subject to rather heavy attacks from the parasite. Different varieties vary in the degree to which they are liable to infestation but the differences are generally small and of no economic importance. An exception must be noted, however, in the case of the variety King Edward, which appears on the whole to suffer decidedly less injury than any other commonly grown variety.

It is realised that the problem of proper utilization of affected land, namely, the adoption of a rotation of several years duration, cannot easily be accomplished in all districts owing to the present depressed state of

agriculture. In many cases the land is extremely valuable and so admirably suited for the growing of potatoes that it cannot carry less lucrative crops. Frequent cropping with potatoes in such instances becomes almost imperative even at the risk in some years of considerable financial loss from the ravages of the parasite. In these circumstances it is suggested as the result of the field experiments, already outlined, and the general field observations made of affected crops that only those varieties of potatoes which can be lifted not later than about the middle of August should be grown on infested land. It is significant in this connection that the exact date when the potato crop should be lifted varies to some extent with different varieties and even in the same variety in another season. Furthermore, tubers from an infected crop should be disposed of soon after they are dug and not, if at all possible, placed in clamps. If for economic reasons clamping becomes inevitable, the potatoes in such cases should be allowed to reach full maturity and stored in a perfectly dry condition, since the presence of moisture greatly favours the rapid putrefaction which almost invariably develops when tubers of an affected crop are clamped.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June,* 1936, *pp.* 61–68.

Further Observations on Occurrence and Incidence of Helminths in British Partridges.

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Since the publication of the results of a survey of partridge parasites in this Journal a year or so ago, some further 234 partridges have been examined and the list of helminth parasites occurring in British birds can be extended. I am once again indebted to Professor R. T. Leiper, F.R.S., under whose supervision the work has been carried out and to Mr. A. D. Middleton of the Bureau of Animal Population, University Museum, Oxford, through whose co-operation many owners of shoots, too numerous to mention individually, have given valuable assistance by forwarding me, for post-mortem work, birds which they have picked up dead on their estates.

The year 1935 has been a good one for the keeper—the breeding rate being high and the incidence of disease low. The weather conditions have been unfavourable, particularly in the first half of the year, for the development of helminths. A dry atmosphere, together with a high temperature, forms the most potent natural factor for the extermination of young stages of Nematodes. The eggs and larvae of *Trichostrongylus tenuis*, the most important parasite in the ecology of the partridge, can withstand considerable cold but desiccation proves inimical to them within a few days. The limiting factors in the case of Cestodes are more complicated and will be discussed later in this paper.

As before, not all the birds sent in were diseased. Many had been shot specially for investigation work while others were very young birds which had died from a variety of causes.

The following additional species of helminths have been obtained this year—*Raillietina cesticillus* (Molin, 1858), *Amoebotaenia cuneata* (Linstow, 1872), *Ascaridia compar* (Schrank, 1790) and *Harmostomum commutatum* (Diesing, 1858). Of these only *Ascaridia compar* has been recorded as a parasite of *Perdix perdix* before and the others are new records.

On the whole helmintic infestation was not heavy. A few birds had died of *T. tenuis* infestation, one as a result of cestodes and one following *Capillaria longicollis* infestation, while a number of deaths among the chickens were accounted for by gapes. Certain birds showed a great variety in their internal fauna ; three in particular each carried 6 different species of helminths and seemed to suffer no ill effects from it.

Cestoda.

The genus *Raillietina* is represented in this year's group only by the species *cesticillus*. It occurred twice. One bird contained 71 scolices. The wall of the small intestine showed an intense enteritis and had ruptured, liberating worms and some contents into the body cavity where peritonitis had developed. Death was attributed to this. The other infestation contained only sexually immature worms to the number of 32 and beyond slight inflammation, no lesions were present.

Choanotaenua infundibulum was again abundant both as regards frequency and numbers—50 specimens or more being recorded in several birds. Although this represented a large bulk of material the hosts did not seem to be seriously affected. The worms were certainly not responsible for death and no reaction existed in the gut wall.

Davainea proglottina occurred 4 times only. On the first occasion only 9 scolices were present, but in the other 3 birds there was a much larger number, running into hundreds, but like the *Choanotaenia*, they were not sufficient to set up any reaction.

The other small tapeworm of birds, *Amoebotaenia cuneata* was recovered once. A few gravid segments of a cestode were observed in the gut contents of a hen partridge but no scolices were seen. The general conformation was familiar but diagnosis was not finally made until the life-cycle had been completed. Light infestations in 2 young Rhode Island Red cockerels were successfully established by means of earthworms.

The genus Hymenolepis was, however, by far the most abundant cestode present in these birds. *H. phasianina* occurred very frequently during the early summer. Two other species, which would seem to be either new or very uncommon, also occurred several times. These will be described at a later date.

Trematoda.

Trematodes occurred once. One partridge contained in its caeca 3 specimens of *Harmostomum commutatum*.

Nematoda.

Nematodes were represented only by fairly common species but certain interesting conditions were observed. *T. tenuis* was by far the most frequent of the intestinal parasites. It occurred 83 times but usually in small numbers. Only in 6 cases was there any marked reaction and in all these the strongyles numbered more than 1,500. They had brought about the death of the birds. The caeca showed the lesions typical of strongylosis and the birds were emaciated. The other infested birds were merely passive carriers with perhaps a dozen or twenty worms. No lesions attributable to their presence could be seen but while the birds were unaffected themselves, they were keeping up the infestation and spreading it over large tracts of land. Given suitable environmental conditions when the young stock comes along, strongylosis will flare up again.

Heterakis gallinae occurred 61 times but the infestations were unimportant from the point of view of disease. Another species of *Heterakis*, probably *isolonche*, also occurred, being found three times. In each case as soon as the birds were opened, it was obvious that the caeca were diseased. They were thickened and of an opaque appearance; the inner surface was covered with small nodules from which *Heterakis* could be expelled by dissection. A similar condition was noted in the previous report when it was suggested that *H. isolonche* was the causative organism. Unfortunately once again the infestation seemed to be of recent origin and none had had time to mature, so that diagnosis was difficult. From certain pre-adult forms which had spicules and the beginnings of papillae, *H. isolonche* is suggested again as an identification.

The genus *Capillaria* was represented by the two species *retusa* and *longicollis*. There were 10 infestations with *C. retusa* and 19 with *C. longicollis*. Among the latter there was one hen bird which harboured 272 specimens all aggregated together in a very small portion of the intestine. They lay in a great mass with their anterior ends embedded in the mucosa. A severe reaction was seen for a distance of about 4 cms. of the gut wall: the lining membrane being very considerably inflamed and

haemorrhagic with petechiae. The gut had become very thin and transparent with severe enteritis. There were no other lesions and death was due here to the presence of so large a number of *Capillaria.*

Only one other intestinal nematode has been recovered ; on 3 occasions *Ascaridia compar* has been found. Only a single male specimen occurred in all the infections and hence in two cases the diagnosis has had to be made by comparisons of females.

Gapes was again of economic importance causing some mortality among the young stock. It has not, however, been particularly high this year, due probably to the fact that the annelid carriers would be deep down in the dry soil and hence not readily available to the chickens.

Time Incidence of Helmintic Infestations.

Very little is known of the length of life of helminth infestations under natural conditions or of the factors that influence them. Certain facts have, however, emerged during the course of this survey which bring up interesting lines of thought.

To consider first the case of *Trichostrongylus tenuis.* When the Commission set up to investigate grouse disease published its report, it was said that strongylosis was essentially a disease of spring, being limited in its epidemic form from April to May. The authors believed that the prevalence of the disease is due mainly to two factors. That during the first few months of the year, there is a shortage of food and the birds are compelled to concentrate on any small areas of moorland that are supporting heather suitable for food. Thus these areas become heavily charged with the droppings of infected birds. As the warm weather approaches, the eggs develop and the infective larvae are liberated. Just at this time too the cock bird is undergoing the strains of mating and moulting and is unable to withstand the additional strain of strongylosis. Hence under these combined strains, cock birds tend to die in large numbers. Although the hen bird is also undergoing the heavy strain of egg laying and incubating, she does not feel the effects of the disease as heavily as the cock. For she is in very good condition, with large reserve stores of food on which she largely lives during the incubation period. She does not eat large quantities of food and so not until later does she have access to infective larvae. This seems to explain why epidemics in hen birds appear later and last longer than in the cocks. Birds which contract the disease about March probably do not die until April and those

which have sufficient resistance to withstand the worst ravages of the disease spend the summer recuperating. During the autumn and winter there is little evidence of disease.

In the case of the partridge a different state of affairs apparently exists. Collinge believes that the disease is not prevalent all the year round, that there is an outbreak at the end of November which steadily increases in severity till mating time, after which it declines. During October many birds finally recover, evacuate the faecal contents and thus spread eggs, in many thousands over the feeding grounds. He seems to think that the conditions for the grouse hold good without any modification for the partridge.

Evidence from the partridges that have been examined during the last three years and from experiments on chickens does not entirely uphold these observations or conclusions. Diseased birds have come in all the year round. A heavy mortality has been apparent from the end of October till December as Collinge has noticed, and this has been mainly in the young birds of that year's hatching. But as in the grouse April and May have also claimed a large number of deaths. These two seasons are not, however, isolated epidemics but rather are the peaks of a disease which continues in chronic form throughout the year. Further, Collinge bases his theory on the fact that infection is practically limited to the late autumn and that the grounds are not seriously contaminated again till the following autumn when the birds are recovering and emptying their caeca. He assumes therefore that infections last for a twelvemonth. This is definitely not the case. Experiments carried out here show quite conclusively that, re-infection being prevented, the intracaecal life of the parasite is limited to about 8 weeks. In fact the whole life-cycle cannot last more than 3 months.

Eggs which have been obtained from partridge and from grouse material were cultured in Petri dishes in chicken faeces until infective larvae appeared. They were then fed to young chickens, R.I.R. cocks, and the resulting infections followed by egg counts. As the caeca only evacuate their contents at irregular intervals, it was not possible to do this every day, but all the caecal contents were collected and examined by the sugar flotation method. By this means the course of the infestation was worked out and the time factor varied scarcely at all when eggs of different host origin were used, *i.e.*, grouse or partridge or later chicken.

On one occasion when a very large quantity of infective material was available, not merely was the parasite transmitted to the chicken but the disease syndrome was set up and the birds died. The caecal contents were solid and the muscular activity of the organs was inhibited. It is the present writer's opinion that when this stage is reached, the disease runs a fatal course and recovery is highly improbable. It is difficult to believe that a bird can live for any length of time when its caeca have completely ceased to function as Collinge seems to assume when he suggests that the caeca are suddenly evacuated in October. These experiments definitely disprove his theory. It would seem to the present writer that the incidence of strongylosis in the partridge can be simply explained by reference to external conditions. In the spring the temperature is increasing, while the atmosphere is still damp so that the eggs which are lying dormant among the vegetation can develop and hatch and set up an infestation. During the summer, the temperature is satisfactory for development, but there is a lack of moisture and many eggs and larvae dry up. In the summer too, the birds feed almost entirely on seeds and flower heads which are unlikely to harbour larvae and therefore the intake is low. These then are the limiting factors in the hot weather. Later in the autumn, the rainy season starts while the air is still warm enough for development and once again we have all the conditions necessary for infection for by this time the birds are finding seeds scarce and begin to feed on rough grass and clover leaves. The degree and number of infections rises rapidly. Later still in the winter, the temperature becomes the limiting factor. Undoubtedly of course, a certain number of eggs and larvae manage to find suitable damp sheltered spots and carry on the infection. The food supply is an important question to consider in the winter. The only food available forms very suitable spots for the collection of strongyle larvae and hence the birds probably pick up many more than they do in the summer. This would account for the prevalence of the disease in chronic form during the winter months. It has been found in this laboratory that infective larvae can retain their infectivity for several months particularly if they are kept in a cool or cold place.

With regard to cestodes the position is less simple as their life-history is complicated by an intermediate host. The incidence is seasonal and the evidence from post-mortems would suggest two facts. First that the life of the individual cestode is short and second that old birds are unlikely to

harbour an infestation. Two cestodes, *Hymenolepis phasianina* and *Choanotaenia infundibulum* are commonly found in British birds and have occurred sufficiently frequently in this series to warrant some remarks on their occurrence.

C. infundibulum is essentially a parasite of late summer and autumn. It appears quite suddenly in the young birds about the end of July or August and persists in great quantity until October when a rapid falling off occurs and continues up to the end of the year. The intermediate hosts are *Musca domestica* and, according to Joyeux, *Geotrupes sylvaticus*. The house flies reach a maximum in summer when the partridges are young and entirely insectivorous in their feeding habits. Heavy infections ensue and this is the only time that they do become infected. The sudden appearance is explained by the sudden appearance of the vectors. The length of life of the worms is not known but it is probably not long as infections die out when the fly vector ceases to be abundant. The worms are occasionally found in birds which have died in the winter months, always however in very small numbers. In over 500 birds, three contained a single specimen between the months of December and July. These infections, however, together with the beetle *Geotrupes*, serve to carry over the infection until the young stock comes along the following year. It has been observed that old birds are rarely affected with the parasite but the present writer can supply no evidence from experimental work as to the cause of the immunity. There may be a natural age immunity or one acquired as a result of previous infestation but it is more likely to depend on the changed feeding habits of the birds.

An even more marked seasonal incidence has been observed in the case of *Hymenolepis phasianina*, the intermediate host of which is not known. This species is almost limited to July. It appears quite early and has never been seen later than the middle of August. This is a very short life span and brings up interesting questions as to the vectors which are being investigated.

Some observations on these lines were made in the Report on grouse disease and have been confirmed in this laboratory. The two most frequent cestodes are *Hymenolepis microps* and *Davainea urogalli*, both of which occur in large numbers. *Hymenolepis microps* appears first in the year, then there is a short period of overlapping and finally its place is taken by *Davainea* and this persists for several months. Once again the

vectors are not known. Knowledge of the intermediate hosts would probably clear up many problems of their appearance. These, too, are being considered.

Summary.

1. *Raillietina cesticillus*, *Amoebotaenia cuneata* and *Harmostomum commutatum* are recorded from *Perdix perdix* for the first time.

2. Some remarks are made on the factors influencing infestation with *T. tenuis*, *Choanotaenia infundibulum* and *Hymenolepis phasianina* in the partridge and *Hymenolepis microps* and *Davainea urogalli* in the grouse.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 69–72.

A new Dorylaimid nematode *Xiphinema radicicola* n. sp.

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Introduction.

In a collection of nematodes received from the Institute of Plant Diseases, Buitenzorg, Java, there were three tubes containing eelworms from pepper gardens on the island of Bangka, Dutch East Indies, where disease of black pepper (*Piper nigrum* L.) caused by the " burrowing " nematode, *Anguillulina similis*, is particularly severe. In one of these tubes were worms which had been collected by Dr. J. van der Vecht from diseased pepper roots grown in a garden at Mabat Oerit, Bangka. Among these were large numbers of *Anguillulina similis*, many *Cephalobus striatus*, one *Aphelenchus avenae*, a few *Dorylaimus* sp. and 30 representatives of the worm which forms the subject of this note. On being cleared and mounted in glycerine it was seen that the buccal spear in all cases was extraordinarily long and closely resembled that figured by Cobb (1913) in *Xiphinema americanum* from which it was concluded that the worms might possibly belong to the genus *Xiphinema*. A question which exercised the writer for some time was whether, following Micoletzky (1921), the genus *Xiphinema* Cobb, 1913 should be considered as synonymous with *Tylencholaimus* de Man, 1876. Having sought the opinion of Dr. Gerald Thorne on this point and receiving word that in his view the two genera are quite distinct, it seemed advisable to describe the nematodes as a new species of *Xiphinema* since they show certain differences from the two members of the genus which have been described up to the present time, namely, *X. americanum* Cobb, 1913 and *X. grandis* Steiner, 1914. The material consisted of 14 young females and 16 pre-adult larval males. No males were present.

Xiphinema radicicola n. sp.

Morphology. Dimensions: length, 2·1 mm. to 2·464 mm., α=62–66, β=5–5·5, γ=31–31·6, V=28·1% to 29·2%, buccal spear, 0·17 mm. to 0·178 mm. Body of almost uniform width throughout its entire length but tapering a little anteriorly in the region of the fore part of the spear and post-anally to the tip of the tail. Cuticle smooth and rather thick; even under the oil-immersion, transverse and longitudinal striations could not be discerned. Head offset by constriction, with convex sides, about twice as wide as deep. No head papillae visible. Buccal spear very long and consisting of two parts; a very slender anterior needle-like portion, making up a little less than two-thirds of the whole organ, and a posterior portion which gradually increases in width and ends in three hollow swellings.

A narrow ring of cuticular material surrounds the second part of the spear a short distance behind the junction of the two parts. Many of the specimens showed the anterior part of the spear exserted for a considerable distance.

The oesophagus consists of two parts; a narrow neck portion which immediately follows the spear and is of a uniform diameter throughout its length and a posterior almost cylindrical muscular oesophageal bulb. The lower end of the neck region is usually bent into a U-shaped loop just before it connects with the muscular bulb.

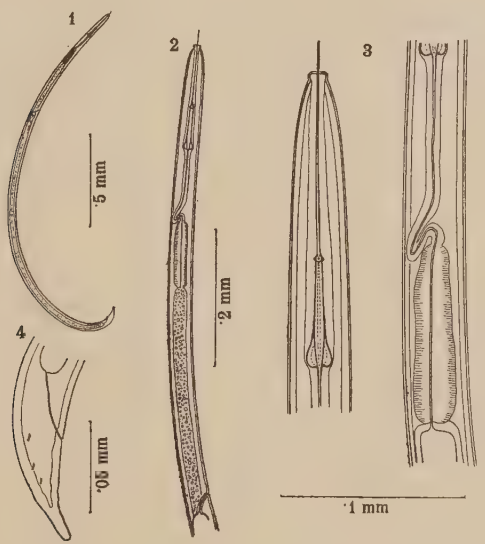
The writer has failed to locate an excretory pore and a nerve ring though numerous ganglion cells are found around the neck region of the oesophagus. The intestine extends from the oesophageal bulb to the rectum which connects it with the anus.

The tail is conical in shape and tapers fairly evenly to a rather narrow rounded point. On the surface of the tail there are three pairs of fine caudal papillae which are only visible under high magnification. They are situated, as shown in fig. 4, more or less towards the dorsal side of the tail. The most anterior is always practically on a level with the anus and, of the other two, the third varies a little in position, being sometimes rather more ventrally placed than as shown in fig. 4.

The vulva is placed rather far forward on the ventral side of the body. The gonad is single and posterior. Owing to the fact that all the adults examined were young, the writer is unable to give any account of the extent of the gonad and the size of the eggs.

Systematics.

Xiphinema radicicola differs from *X. americanum* Cobb in its greater length, its slenderer build, its more forwardly placed vulva (the latter in *X. americanum* being immediately post-equatorial) and in having a single gonad as compared with paired, opposed ones. When compared with *X. grandis* Steiner the new species differs in the following points :—it is longer, slenderer, has a tapering, conical tail whereas that of *X. grandis* is blunt and rounded. The vulva also in *X. grandis* is situated at 40% of the body-length from the anterior end whilst in *X. radicicola* it is at



Xiphinema radicicola n. sp.

Fig. 1. Drawing of entire worm in lateral view under low magnification to show shape and general proportions.

„ 2. Fore part of body to show relative extent of spear and oesophagus and forward position of vulva.

„ 3. Spear and oesophagus under high magnification ; the dotted lines in the second part of the spear indicate the third swelling.

„ 4. Tail in lateral view under high magnification showing general shape and distribution of caudal papillae.

28%–29% of the body-length. In *X. grandis* the ovaries are paired. On these grounds, therefore, it is considered advisable to establish a new species.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 73–76.

A New Trichostrongylid (*Minutostrongylus taurotragi* g. et sp. n.), of the Sub-family Heligmosominae from an African Antelope.

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During the examination of a large number of nematodes collected by the writer in 1931 from the duodenum of a male eland (*Taurotragus oryx*) shot in the Nega Nega Hills, north-east of Mazabuka, three (two males and one female) specimens of a rather small species of Trichostrongylid were recovered. As the species could not be assigned to any of the known genera of bursate nematodes the new genus *Minutostrongylus* is founded for the reception of this species which is named *Minutostrongylus taurotragi* g. et sp. n.

MINUTOSTRONGLYUS g. n.

Definition.—Heligmosominae : Rather minute worms ; body filiform, not spirally rolled ; cuticle with well marked longitudinal lines or ridges and less prominent transverse striations ; anterior extremity rounded with oral aperture anterior and not bounded by prominent lips ; circumoral papillae present but not conspicuous ; cephalic cuticle show varying degrees of inflation ; cervical papillae just anterior to base of oseophagus and poorly developed ; excretory pore well anterior to cervical papillae ; oesophagous relatively long.

Male.—Bursa well developed and symmetrical, lateral lobes project posteriorly beyond the margin of the dorsal lobe ; bursal rays well developed and divided into three distinct groups (ventrals, laterals and dorsals). Ventro-ventral and latero-ventral rays have a short common stem and are long and diverging with their distal portions widely separated ; antero-laterals shorter but stouter than the medio-laterals with which it shares a common stem ; postero-laterals longer than the medio-laterals ; externo-dorsal rays well developed and lying practically parallel to the postero-laterals which they equal in thickness ; dorsal ray short and rather stout,

bifurcates about half its length into two branches each of which almost immediately divides into two branches and the two medials are directed posteriorly and end in well marked bidigitations while the lateral (or ventral) branches are posteriorly and laterally (vertrally) directed. Gubernaculum or accessory piece present but not strongly chitinised and with caudal end in the prominent genital cone. Posteriorly and ventrally the genital cone shows the presence of two structures which resemble papillae or ducts. (Similar structures are present in the various species of *Trichostrongylus*, *Cooperia* and *Ostertagia* recently examined by me and it would seem that they are the ducts of the cement secreting tissues.) Spicules long and filiform, equal in length, brown in colour, well chitinised, alated medially and each terminating distally in a very fine point. Prebursal papillae fairly well developed.

Female.—Genitalia single, ovejectors well developed and consisting of a long, not markedly muscular, anterior portion, a prominent sphincter and a strongly muscular terminal portion followed by a long vagina ; vulva a transverse slit with prominent lips and close to the anus ; caudal extremity rather blunt ; caudal papillae situated at base of a short caudal spike. Parasite of ruminants.

The fact that the specimens of *Minutostrongylus taurotragi* are not spirally coiled serves to differentiate the new genus from the genera *Heligmosomoides* Hall, 1916, *Nematospira* Walton, 1923, *Viannaia* Travassos, 1914 and *Viannella* Travassos, 1918. It can be readily differentiated from the other genera of the subfamily Heligmosominae Travassos, 1914, if the key to the differentiation of the genera, given by York and Maplestone (1926) is amended as follows :—

1.	Lateral lobes of bursa and rays markedly asymmetrical ...	*Nippostrongylus*
	Lateral lobes of bursa and rays approximately symmetrical	2
2.	Tail of female ends in three or more cusps ; vulva not close to anus	*Ollulanus*
	Tail of female not ending in three cusps ; vulva close to anus	3
3.	Body not coiled in a permanent spiral	4
	Body coiled in a permanent spiral	6
4.	Dorsal ray completely doubled	*Heligmostrongylus*
	Dorsal ray only forked at its extremity	5

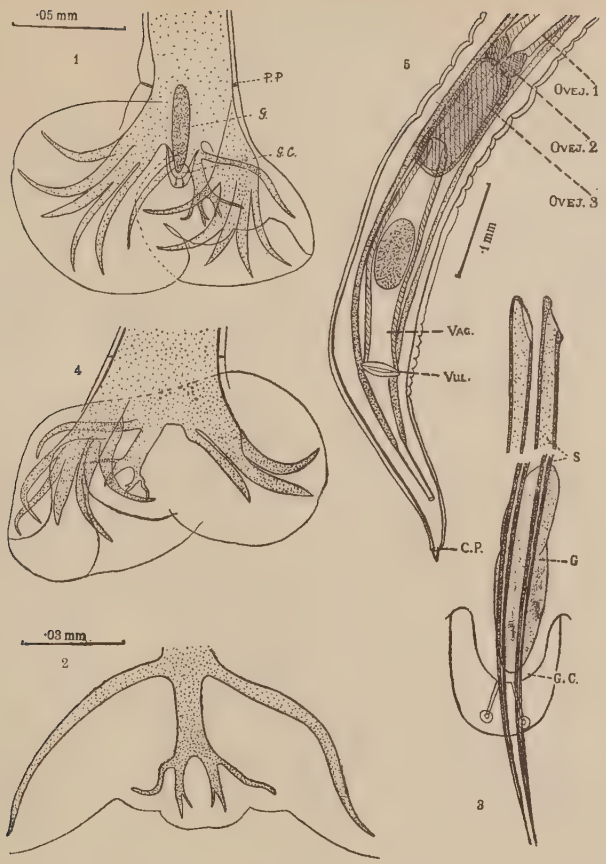

Fig. 1. Dorsal view of bursa of Type Specimen. G., gubernaculum, G.C., genital cone, P.P., prebursal papillae.

„ 2. Dorsal Ray and Externo-dorsal Rays.

„ 3. G., gubernaculum, G.C., genital cone, S., spicules.

„ 4. Ventral view of bursa showing abnormal rays in left lateral lobe.

„ 5. Posterior extremity of female, C.P., caudal papillae., Ovej. 1., anterior portion of ovejector, Ovej., 2, sphincter of ovejector, Ovej, 3, muscular portion of ovejector, Vag., vagina, Vul., vulva.

5. Cervical cuticle studded with papillae; dorsal ray very long ... ... *Impalaia*

Cervical cuticle not studded with papillae; dorsal ray relatively small, postero-lateral ray much stouter than medio-lateral ... ... *Heligmosomum*

Cervical cuticle apparently not studded with papillae; dorsal ray well developed but not long; postero-lateral ray longer but not stouter than medio-lateral ... ... *Minutostrongylus*

Of the genera mentioned above only *Impalaia* species have hitherto been recovered from ruminants in the Union of South Africa, Northern Rhodesia and Kenya. In Kenya, *Impalaia nudicollis* Mönnig, 1931 is recorded as a parasite of sheep.

Minutostrongylus taurotragi g. et sp. nov. The two males and the female, recovered from the eland, are not too well preserved since the worms were only collected from the duodenum after this organ had been removed for twenty-four hours.

The one male showed marked inflation of the cuticle anteriorly and on various parts of its body. This should probably be attributed to the putrifactive changes which took place after the removal of the infected organ. These worms were collected in March 1931 and had not been described as it was hoped that more material might become available.

The best preserved male measures 4·8 mm. in length with a maximum body diameter of 56μ in front of the bursa which has a lateral diameter of about 200μ. The spicules are 580μ long and the gubernaculum is about 60μ. The dorsal ray is about 40μ long.

The female is slightly better preserved than the males and the various measurements are as follows:—length of body 6·1 mm., maximum width at vulva 88μ, length of oesophagus, 645μ, distance of excretory pore from cephalic end 165μ, cervical papillae to cephalic end 585 μ. Diameter of head 18μ, anus to tip of tail 52μ. Vulva to tip of tail 178μ, caudal papillae to tip of tail about 8μ. Measurements of eggs in vagina 78 × 35μ.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 77–84.

Observations on the Occurrence of *Anguillulina dipsaci* (Kühn, 1858) on Rhubarb in Yorkshire.

By L. R. Johnson, M.Sc.

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The list of recorded hosts of *A. dipsaci* given by Goodey (1929 and 1933) includes rhubarb, and records and observations in Yorkshire show that infestation by this eelworm is widespread in the rhubarb-growing districts of the county. It is important, at the outset, to note that as far as the writer's observations are concerned the eelworm invariably occurs in rhubarb plants suffering from a disease well-known among growers as Rhubarb Disease or Crown Rot. The following account must therefore include recurring references to this disease with which the eelworm appears to have an intimate association. The earliest records with regard to the disease appeared in the Journal of the Northern Horticultural Society but as this Society has been discontinued a brief summary of these records is given. In the February 1913 issue of this Journal, Hector and Taylor (1913) summarised various notes on the disease. They referred to an editorial in " The Fruit Grower " (9th January, 1913) concerning examination of diseased rhubarb roots received from Yorkshire in 1909 and again in 1913. The editorial stated that the roots received in the earlier year were infested by fungi, bacteria and eelworms identified as *Tylenchus devastatrix* whereas the plants received in 1913 harboured the same three types of organisms but it was thought that the parasitic eelworms were of some species of *Aphelenchus*. The March 1913 issue of the same Journal included a copy of a letter from the Board of Agriculture and Fisheries reporting on an examination of diseased rhubarb roots received from a Yorkshire grower. The letter stated that examination " failed to reveal the presence of any disease or pest other than the Stem Eelworm with which the plants were badly infested." Taylor (1914) referred to the presence in diseased rhubarb plants of parasitic eelworms belonging to the genus *Tylenchus*. He also stated that as he found the parasites chiefly at the junction of sound and healthy tissues he concluded that in some cases at least the eelworms were the chief agents in starting Rhubarb

Disease. Later in the same year Lebour & Taylor (1914) recorded the presence of *Tylenchus devastatrix* in diseased rhubarb. Goodey (1929) commented on the presence of *Tylenchus devastatrix* in diseased rhubarb received from Yorkshire and suggested that in view of Millard's bacteriological investigation referred to later, the eelworm might help in spreading the disease. The disease was investigated in 1915 and later in post-war years by Millard (1924) and the results of his experiments led him to conclude that the causative organism was a bacterium which he named *Bacterium rhaponticum*. Millard makes no reference to the presence of parasitic eelworms in diseased plants and although his inoculation experiments gave conclusive results, the occurrence under field conditions of *A. dipsaci* in diseased rhubarb is a factor which in the writer's view, cannot be overlooked. The writer has had ample opportunity of examining rhubarb plants and observations suggest that the rhubarb strain of *A. dipsaci* is not only an interesting example for study in relation to biologic strains of the species but it is felt that the problem as to whether the eelworm is actually a primary factor or not in the production of Rhubarb Disease is worthy of further investigation. The present account deals mainly with observations on the occurrence of the eelworm more especially in dormant root stocks.

Occurrence of the Stem Eelworm in Dormant Root Stocks.

The many diseased root stocks examined by the writer were largely of the varieties "Victoria" and "Prince Albert." The symptoms of "Rhubarb Disease" have been described by Millard and reference should be made to his well illustrated publication. It is convenient, however, to indicate the internal symptoms of the condition. Millard states that the disease "would be better described as Rhubarb Crown Rot, for it is the crown of the plant which is most generally attacked and when the disease has reached its zenith, the whole crown of the plant is easily kicked off with the foot or comes away when the rhubarb is pulled. Below the crown, the flesh is found to have been converted into a chocolate-black, spongy mass which severs it from the tissues below." Referring to the early stages of the disease Millard points out that infection usually originates in the set near soil level and just below a bud from which point "a brown discoloration is seen extending into the flesh." From this stage the decay progresses into the tissues of the root stock. The same

writer observed the disease in the buds which were infected without the condition spreading into the crown. Finally he records the frequent occurrence of the disease in the fang roots and seems to be of the opinion that in these cases the infection spreads from these sites into the main root.

The present writer's observations on the occurrence of *A. dipsaci* in diseased root stocks are of interest in relation to these symptoms of Crown Rot. It has already been stated that Crown Rot appears to be accompanied always by eelworm infestation and examination confirms Taylor's view that the heaviest eelworm infestation occurs in the region where the diseased tissue is adjacent to healthy tissue. Fig. 1 is a photograph of a very badly diseased root cut longitudinally. The extent of the disease is easily seen and it will be noticed that the bud has been destroyed. From specimens such as this large numbers of the Stem Eelworm in all stages of development are easily obtained, especially where the decay is passing into healthy tissue. Fig. 2 is a photo-micrograph showing eelworms present at such a site. The thin slice of tissue photographed was treated by the method recently described by Godfrey (1935). In those parts suffering from advanced rot soft parasitic forms can be found but the majority are dead and discoloured. In such sites, however, secondary non-parasitic forms such as *Diplogaster* and *Cephalobus* are very abundant. In specimens suffering from the disease in its earlier stages it has been possible for example to find the disease confined to the region immediately below the base of a bud. Careful slicing of such materials has shown the disease extending into the underlying flesh ; sometimes the cut face showing two or three wedge-shaped areas or thin strands of discoloured tissue easily overlooked. Parasitic eelworms are always very abundant in those regions where the disease is clearly invading healthy tissue. Fig. 3 is a photograph of a portion of a root stock cut through transversely about one inch below a bud immediately below which the parts were extensively decayed and dark brown in colour. The cut face of the lower portion of the specimen, seen in the photograph, shows that the disease was passing in this case from the base of the bud by way of what was, in the specimen, a ring of light coloured tissue carrying vascular elements. The lesions showing in the photograph were of a light brown colour and not yet in the soft rot condition present in the parts immediately below the bud. The photograph also shows a strand of diseased tissue exposed in the basal

region of a fang root. Dissection revealed that the lesion in the fang root was continuous with that in the root stock and it was possible to detect the ultimate end of the diseased strand in the healthy tissue of the fang root. *A. dipsaci* was present in very large numbers in the diseased tissue represented in the photograph and it is clear that in this case, which is typical of others in the writer's experience, that the eelworm infestation was in process of passing down into the fang root from the region below the bud. Such observations are contrary to Millard's opinion that the disease may in some cases pass up the fang root and then into the root stock.

Observations such as those described show quite clearly that the active eelworm infestation is in advance of severe rotting which is a common sequel to eelworm attack in other hosts. In this connection, a comparison of the typical internal symptoms of Crown Rot of Rhubarb with those summarised by Goodey (1929) from Ritzema Bos' description of the effect of *A. dipsaci* in Mangolds, reveals a striking similarity. In both cases the usual point of entry of the disease is near soil level and the extension of the disease results eventually in a soft discoloured rot with the result that the crown of the plant is easily detached. Millard's experiment, however, showed that root stocks grown in soil inoculated with cultures of *B. rhaponticum* contracted the disease whereas control roots showed no signs of the disease. Provided the root stocks in the inoculated group were free from eelworm infestation it must be assumed that the micro-organism is alone capable of producing Crown Rot. The heavy infestation by *A. dipsaci* in diseased plants in the field as described in the foregoing account cannot fail strongly to suggest that the eelworm is of primary importance in the development of Crown Rot.

Factors affecting Eelworm Infestation.

Millard has discussed fully the factors which predispose to the incidence, persistence and increase of Crown Rot from the point of view of a bacterial disease. Many of his recommendations naturally apply also to the question of eelworm infestation and his investigations have done much to develop amongst growers a proper sense of plant hygiene.

1. *Type of soil.*

The disease with accompanying eelworm infestation seems to be definitely more prevalent on the lighter type of soil.

Fig. 1. Portion of rhubarb plant sliced longitudinally to show typical advanced symptoms of Crown Rot.

Fig. 2. Photo-micrograph of section of eelworm-infested rhubarb tissue taken from advancing edge of disease in specimen shown Fig. 1.

Fig. 3. Portion of diseased rhubarb plant sliced transversely showing lesions heavily infested by *A. dipsaci*.
Note lesion extending into base of fang root.

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2. *Cultural Methods.*

Given an initial eelworm infestation of the soil or of the plants the normal procedure of allowing root stocks to remain in the ground for two or three years before lifting obviously encourages the spread of the eelworm both in the plants and in the soil. It should be noted that apparently healthy roots may become diseased during their first year in the field although it is usually later that the trouble becomes evident. In bad cases many roots may be killed or so badly diseased that they are useless at the end of their period. When root stocks are split for purposes of propagation the progressive grower attempts to discard all diseased material but the nature of the roots is such that early stages of the disease are easily overlooked. Many good growers, unfortunately, instead of rejecting completely all diseased roots attempt to cut off the diseased parts and use the apparently healthy remainder.

On some holdings where the disease occurs in isolated patches it has been observed that the area of each patch in subsequent years has extended largely along the direction of cultivation of the field.

3. *Disposal of infested debris.*

Millard rightly condemned the practice of ploughing in diseased débris for manurial purposes and as a result many growers have discontinued this practice. The heap of discarded roots which accumulates after forcing is a fertile source of *A. dipsaci* and the disposal of such heaps which may attain a great size is a problem when it is realised that their use for manurial purposes is bad practice. It is obvious from the point of view of avoiding spread of eelworm infestation that destruction by burning of diseased roots as soon as they are observed is the best method of dealing with this source of contamination and this is already practised by many growers.

The growth of rhubarb plants as ground-keepers which may appear in alternative crops provides a potential source of eelworm infestation to the following rhubarb crop.

4. *Rotation.*

The custom in the early days of rhubarb culture of continuous cropping with rhubarb has long been discontinued. The type of rotation varies with the holding. Many growers rest the land for one year, only growing brassica crops as an alternative ; others give a rest of two years, peas and

brassicas or turnips being commonly grown. Some growers, especially those who are more general farmers, use a wider variety of crops such as oats, potatoes and one year seeds ley in addition to the crops already mentioned. In the majority of cases the land is rested for one year only and never more than three years.

The use of oats which was one of the crops recommended by Millard raises an important question. A number of growers in the past grew oats as an alternative crop to rhubarb. Experience, however, has shown that continued inclusion of this crop appeared to result in an increase rather than a reduction in the amount of the disease. The substitution for the oat crop of a brassica crop led to a very considerable decrease in the trouble from disease even when such a crop was the only alternative to rhubarb. It is realised that those growers who are progressive enough to make alterations in rotational cropping are more likely to practise as far as possible general hygienic measures concerned with the prevention of disease. Nevertheless, the unshakeable belief exists among certain growers that the continuation of oat cropping would have spelt ruin for the rhubarb crop on their farms. If the disease is a true bacterial rot it is not easy to understand the beneficial effect of substituting a brassica crop for oats in reducing the incidence of the disease unless the repeated intercultivation necessary for such a crop accelerates the rotting down of infected plant material, thereby reducing the bacterial infection in the soil. If, on the other hand, the Stem Eelworm is a primary factor in causing the disease it might be inferred that the rhubarb strain of the eelworm is capable of passing over on to oats thereby maintaining an active eelworm infestation in the soil. Eelworm injury of the oat crop has been observed in the past on holdings on which this crop was used to provide a rest of one year from rhubarb. The writer also obtained, during the autumn of 1935, the eelworm in small numbers from old oat stubble on a farm where trouble from disease in the rhubarb is very considerable. Preliminary experiments have therefore, been carried out with the object of ascertaining whether the oat strain and the rhubarb strain of *A. dipsaci* are reciprocally infective.

Infection Experiments.

The first experiment was concerned with an oat strain of *A. dipsaci* obtained from the North Riding of Yorkshire where trouble from the

eelworm frequently occurs and where rhubarb is not cultivated. Dried infested oat material was incorporated with sterilised soil in five pots. Rhubarb seedlings of the variety " Victoria," raised in sterilised soil, were transplanted one in each pot and placed in a cool greenhouse. Seedlings were also grown in soil free from eelworm infestation. One of the seedlings died off early and of those remaining two were examined two months after transplanting. One seedling was free from infestation and from the second only very few parasitic eelworms were obtained by soaking the grown region in water. The fourth seedling was examined a month later by which time the leaves had died off and decayed and new ones had not yet developed. Again only a few eelworms were obtained from the old brown sheaths around the crown. The last seedling had by this time lost two of its leaves. The third leaf stalk was rotten and split at the base. The leaf itself was free from infestation but the stalk proved to be very heavily infested by all stages of *A. dipsaci*. The infestation was confined to the middle portion of the petiole, the rotten base being invaded by secondary non-parasitic forms and the distal portion being free from infestation. The fourth leaf was dying and the petiole was soft and swollen. Dissection again revealed heavy parasitic infestation which was restricted to the proximal half of the leaf petiole. Three weeks later the seedling was lifted. The two remaining leaves and their stalks were not infested. The rest of the plant, however, proved to be infested by all stages of the eelworm and the infestation extended into the fang roots.

A similar experiment was carried out on oats using eelworm-infested rhubarb material. Black Winter Oats were sown in sterilised soil in pots in a cool greenhouse in November 1935. Small chips of dried infested rhubarb material were introduced into the top layer of the soil in two of the pots as soon as the young oat shoots broke through the surface. Four pots were kept as controls. Three weeks after the introduction of the rhubarb material the single leaf of each plant showed small pale chlorotic areas and some of the leaves showed early signs of distortion. Dissection of specimen leaves revealed large numbers of *A. dipsaci* and the bases of the plants were also heavily infested. The chlorotic areas extended as time elapsed, the second shoots being also invaded. Stunting of growth and swelling of the basal region of the plants soon became obvious in comparison with the controls which remained free from any eelworm attack.

The results of these preliminary experiments, which are being repeated, provide evidence additional to that obtained from field observations that

the oat and rhubarb strains of *A. dipsaci* are reciprocally infective. It would seem, moreover, that the contention that oat cropping in the rotation on rhubarb farms leads to a serious increase in the amount of Crown Rot is intimately bound up with the persistence of eelworm infestation on the holding due to its transference from rhubarb to oats and *vice versa*. This being the case the importance of *A. dipsaci* as a primary factor in the spread of Crown Rot seems to be established. In view of Millard's investigation which established the primary parasitic nature of *B. rhaponticum* in pot experiment it would appear at present safest to assume that micro-organism alone can produce Crown Rot but that in the field the incidence of the disease is increased very considerably by eelworm attack which is always present and in advance of bacterial rotting. Given healthy root stocks when conditions are such that eelworm infestation in the field is largely prevented the disease appears to be largely controlled.

The writer desires to express his thanks to his colleague Mr. C. E. Hudson for his help in obtaining material and to Mr. J. Manby for the photographs.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 85–92

On the Incidence of the Abomasal Parasites in the Lambs of South-West Britain.

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Ostertagia circumcincta (Stadelmann, 1894), *Haemonchus contortus* (Rudolphi, 1803) and *Trichostrongylus extenuatus* (Railliet, 1898), are the three species of nematodes most commonly met with in the abomasum of the sheep, and all may play a part in the development of the disease called parasitic gastritis, though each species, under different conditions and in different areas, may assume a different individual importance. In South Africa, New South Wales, and the greater part of the U.S.A., *Haemonchus contortus* is mostly involved, while in certain areas of the latter country, particularly on the West Coast, in New Zealand, and in the Southern Australian states, *Ostertagia circumcincta* is also of importance. In this country, however, *Ostertagia* appears to be of far greater importance than any other worm, and is, in many parts, a very serious pest of sheep farming. Since the report of M'Fadyean (1897) on " Parasitic Gastro-Enteritis in Sheep and Lambs " its occurrence and supposed pathogenic action has been noted from time to time, but it is only comparatively recently that systematic surveys have been taken of the intestinal fauna of the domestic animals, and even yet it is not possible to gauge accurately and definitely the range and prevalence of any particular species. For most nematodes of economic importance figures are wholly lacking, and for *Ostertagia* the most that can be said is that it is of common occurrence, and the cause of disease in certain areas. Sometimes it occurs " in small numbers," sometimes it is " fairly numerous," at other times it just " occurs," and rarely a few figures are given.

Cameron (1923) in his work in Scotland found *Haemonchus* on various occasions in the Lowlands, and " *Ostertagia circumcincta* and *O. trifurcata* were usually found in association with it, but always in small numbers." He gives figures for these worms in four lambs :—

1.	14	*Haemonchus contortus*,		8	*Ostertagia*.
2	10	,,	,,	6	,,
3.	14	,,	,,	20	,,
4.	21	,,	,,	7	,,

Morgan (1924) from the Aberystwyth area of Wales reports that " *Ostertagia circumcincta* was of frequent occurrence throughout the period and was the only Trichostrongyle found in any numbers during the early months of the year," and in a further communication (1925) he says that " *H. contortus* was comparatively rare during spring and early summer, but increased in August and September. . . . *O. circumcincta* was one of the most common species, occurring in both sheep and lambs throughout the year, and was more commonly met with during spring and early summer than *Nematodirus filicollis*."

Lewis (1930) continued Morgan's work. During four years he examined just over 600 sheep, and found an average infection with *Ostertagia* of 36·2%. He gives 27 counts varying between 1 and 120 with an average of 32·4. *Ostertagia circumcincta* and *O. trifurcata* (very rare) " were rarely found in the older lambs and adult sheep, and particularly so during January, February and March. Although very large numbers have been collected from individual hosts, no cases of death caused by these parasites have been reported or traced in any of the districts surveyed." *Haemonchus* was " neither so common nor so abundant as *O. circumcincta* ; it was most common from July to November."

Brade-Birks (1927) finds that " *O. circumcincta* is common and quite often numerous in the fourth stomach " of sheep from South-Eastern England.

During the last few years the economic necessity of knowing far more details of worm infestation in sheep has become generally recognised, and in an effort to solve some of the problems the Rowett Institute, with the North of Scotland College of Agriculture, planned a large scale campaign. All their results are not to hand, but some interesting and important features have already been published. Robertson & Fraser (1933) conclude that " parasitic gastritis in the North of Scotland is mainly due to *O. circumcincta* and that any control measures directed with a view to checking the disease should be carried out against this parasite." They give figures for two typical cases of diseased lambs. In the abomasum there were :—

O. circumcincta	16,930	18,110
H. contortus	53	76

In a consideration of the disease in the light of these results Orr and his co-workers (1934) observe that " There is a great deal of work to be done

in finding out the number of worms harboured by lambs under different conditions. There is too little information available regarding the number of worms in healthy lambs compared with that in those that are sick " . . . and wonder if " the same kind of worms are responsible for damage in all parts of the country, or are there worms thought harmless which may be harmful under certain conditions and in certain districts."

It was to answer these and similar questions that the present survey of the abomasal parasites was done.

Material and Technique.

The worms were collected from lambs killed at a local abattoir. The latter receives stocks from districts as scattered as Haverfordwest, Margam near Port Talbot, Abergavenny, Monmouth, Hereford, North Wales and Exeter, and material from each of these districts was examined. In the beginning attempts were made to determine the exact original location of the lambs, but as they were usually bought at marts held in the above towns, the determination proved too difficult and involved. However, as the investigation proceeded, it was seen that knowing this original locality would not materially help in the interpretation of the figures.

The lambs were for the most part " Spring Lambs " born towards the end of January, in February, or in early March. They do not make their appearance at the abattoir in any numbers until the end of April, and are then roughly two months old. Afterwards, of course, their age can be more or less gauged from the month in which they were slaughtered—in the statistics those of January 1935 are nearly a year old, those of August 1935 about six months.

The method commonly adopted in the separation of worms from gut contents is that of Ransom (1911). The gut contents, with the washings of the mucous membrane, are poured into tall containers. Water is added and the contents stirred and allowed to stand for a few minutes. The worms, together with the heavier ingesta, settle towards the bottom of the vessel, and the supernatant liquid, except for the lower few inches, is decanted, and more water added. The procedure is repeated until turbidity no longer appears in the supernatant layer. The contents are then poured into a shallow dish and the worms picked out. This method was not used by the writer because the worms were required in as

unharmed a condition as possible for an experimental investigation, and the following method seemed to be better suited to this purpose :—

The abomasa of lambs which had rarely been killed more than half-an-hour previously were cut at the pyloric sphincter and the contents poured into jars. The mucous membranes were washed with Ringer warmed to 40° and the washings, together with the contents, were incubated at 39° during the short time which lapsed before their examination. For the latter the contents of the various jars were poured in a shallow layer, about 1/10″—1/8″ deep, into a petri dish placed over a light. The worms, as a rule, were readily seen swimming actively through the solution and could be picked out with a needle, though occasionally it was necessary for the stomach contents to be diluted with Ringer for the movements to be apparent. The immediate examination of the abomasum and the use of Ringer are necessary precautions if the worms are to be used for experiment, but if a census is the only requirement the stomachs can be left for 24 hours or more, and water used as a diluent, and the worms will still be capable of movement on warming.

The method has certain advantages over Ransom's, especially when dealing with small nematodes. The process of sedimentation and decantation, which can be rather lengthy, is dispensed with, and, what is more important, it is certain that all the worms are picked out, an assumption that cannot be made with the sedimentation method, for often the smaller species like *Ostertagia* and *Trichostrongylus* may be clinging to the floating detrital material which is poured off.

The Degree of Infestation.

During the course of the year some 600 lambs (roughly 12 per week) were examined, and failure to find *Ostertagia circumcincta* was met with on only five occasions ; *Haemonchus contortus* was present in 32% of the cases, and *Trichostrongylus extenuatus* in much lower proportion. Very occasional specimens of *Nematodirus filicollis* (Rudolphi, 1802) were also found, but more than two were never present at the same time.

An accurate calculation of the *Trichostrongylus* incidence cannot be given because a detailed examination of the entire contents of the abomasa of all the 600 lambs was not undertaken, and without such a close scrutiny a very low infestation with such a small nematode as *Trichostrongylus* might easily be missed. However, from the counts it is seen that its occurrence is sporadic and sparse.

STATISTICS OF THE INFESTATION OF SHEEP WITH ABOMASAL PARASITES.

Date.	O. circ.	H. cont. F.	H. cont. M.	T. ext.	Date.	O. circ.	H. cont. F.	H. cont. M.	T. ext.
1934.					Mar. 18	740			
Oct. 17	68	5	2		,, 19	30			
,, 22	105					22			
	281				,, 20	600			
,, 23	156				,, 26	53			
	234	6	4			231	2	3	276
,, 30	186	28	5		*May 7	140			
	65					0			
Nov. 1	165					0			
	73	50	6		,, 8	813			
,, 5	104				,, 13	277			
	341				,, 20	526	1		
,, 7	173	3	1		,, 28	107			72
,, 12	267					143	1		
,, 14	308				Jun. 3	368			
,, 19	146					252			
	252				,, 4	351			
,, 21	37	2			,, 17	1,045	3		
,, 22	125				,, 25	3,270	1		
,, 26	217				,, 28	1,302			
Dec. 4	212					732			
	303				July 3	1,389	1		
,, 11	60	1				300	2		33
,, 18	163					71			
					,, 8	149			58
1935.						190	2		
Jan. 2	127					97			
	244				,, 10	257			
	53					134			
,, 7	209	1	2		,, 11	1,346		3	143
,, 8	304					214		2	
	46	4	7		,, 23	273			78
,, 9	289				,, 25	157			
,, 14	611				,, 29	163		4	27
	170	2			,, 30	824	66	54	
,, 15	660					18			3
	272				Aug. 1	157	3	3	9
,, 21	280					756		1	39
,, 23	140				,, 7	93			
	223					1,212			
,, 29	302					342			
,, 30	193			360	,, 8	592	3	8	
Feb. 6	831					293	4	5	
,, 11	323	4	3	52		122			12
	109				,, 14	86			
,, 26	15					371	40	32	
	23				,, 19	756	12	9	74
,, 27	237					504			
Mar. 4	189				,, 20	1,315	4	2	53
,, 5	347				,, 22	84	1	3	
,, 11	241					244	12		

*Appearance at the abattoir of the Spring Lambs.

Time would only permit of counts being done in 100 instances ; as far as possible these were distributed regularly through the year. In the Table there are no figures given for April, but owing to pressure of other work this absence of representation was unavoidable. However, throughout the month *Ostertagia* (grouped as *O. circumcincta* but possibly contaminated with *O. trifurcata*, though very lightly) was being taken and used regularly, and the numbers present did not appear to differ in any very noticeable way from those of other months. The counts are, for the most part, random samplings, but in the latter half of June the greatest contaminations were looked for with a view to obtaining an idea of the highest number of the abomasal parasites it is possible for an apparently healthy young lamb to carry. The highest count thus obtained was 3,270, nearly 2,000 higher than the nearest of the others.

Discussion of the Statistics.

Without further information, the easiest and most obvious explanation of the *Haemonchus* and *Trichostrongylus* figures is to assume a scattered and light infection with these nematodes of most of the sheep districts considered. The sex ratio of *Haemonchus*, so largely unequal, would appear to support this view. *Trichostrongylus* seems to be more prevalent in the summer months.

Ostertagia is regularly present and the figures are comparatively high. They are at least high enough to postulate a heavy infection of the grazing grounds with the larvae of this worm. Why then should these figures, even though high, be so much lower than the figures given by Robertson & Fraser based on their examination of lambs suffering from disease caused by the worms ? There are two possible reasons : either there is a heavy field mortality of the larvae, which is improbable ; or a resistance to the accumulation of the parasites is present within the lambs. It is reasonably safe to assume the latter, but no adequate idea of the nature of the resistance can be given, though something of its complicated nature may be pointed out—it is such that it is capable of keeping the numbers below those usually associated with disease (10,000+), and yet is capable of allowing a residual infestation. This is a tantalising feature characteristic of by far the greater majority of the examples of helminth immunity, and only rarely does the resistance confer an absolute immunity upon the host. Again, the resistance to the presence of *Ostertagia* varies in the different lambs, and is lowest in certain of the young lambs during the summer

months when counts in the region of 1,000 are more frequently made. It is probably dependent for its full development upon an adequate nutrition.

The lambs were apparently healthy in every way, and supplied the highest class of meat obtainable in Cardiff. They would certainly be described as " well-fed," but whether further feeding experiments would lower the numbers present still more remains to be seen. Whatever the full reason for the development of the resistance, and whatever the full reason for the difference between a lamb carrying 50 *Ostertagia* and another carrying 1,000, the importance of nutrition in its relation to helminth immunity cannot be too strongly emphasised.

Impetus was given to the study of the effect of diet on helminth infestations by the work of Hiraishi (1928) on the prophylactic action of vitamin A in Ascariasis, and since then quite a number of experiments have been done showing that avitaminosis may increase the numbers of worms present ; but perhaps of more significance to methods of sheep husbandry is the work of Clapham (1934) who showed that chicks receiving a diet coefficient in Calcium and Phosphorus had far more *Heterakis gallinae* Gmelin (1790) present than did the control group receiving a full complement of minerals. Clapham's experiments point to the use of mineral concentrates in sheep feeding. That good results should be forthcoming from further research on the diet of sheep in its relation to helminth infestation is suggested by the work of Fraser & Robertson (1933) in Scotland, and Ross & Graham (1933) in Australia. The former authors showed that a generally inadequate diet lowered the resistance of sheep to *Haemonchus contortus*, and the latter authors reached the conclusion that adequate nutrition was far more effective in improving the condition of sheep infected with small Trichostrongylid worms than drug treatment.

Conclusion.

Sheep are capable of developing a resistance to the presence of *Ostertagia circumcincta*. Adequate nutrition has a great deal to do with this development, and it is suggested that, until an effective drug treatment is found for this worm, more attention should be paid to the food of sheep.

Summary.

An account is given of the incidence of the abomasal parasites in the lambs of South-West Britain. Some 600 lambs were examined, and counts of the parasites were conducted in 100 cases.

It is suggested that to explain the constancy of infection with *Ostertagia*, and the great difference between these " healthy figures " and the pathogenic figures (10,000) of other authors, it is necessary to assume a resistance to the accumulation of the parasite present within the sheep.

ACKNOWLEDGMENTS.

The work was done in the Zoological Laboratory of University College, Cardiff, and I wish to thank the staff, especially Professor W. M. Tattersall, for their help.

I also wish to record my appreciation of the courtesy shown me at the Roath Abattoir, Cardiff, where the material was collected.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 93–98.

On *Aphelenchoides hodsoni* Goodey, attacking narcissus.

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For many years it has been recognised that the nematode, *Anguillulina dipsaci*, is a major pest of narcissus, and growers and scientific workers alike are familiar with the presence of damaged and discoloured tissues within the bulbs, accompanied by swelling and distortion of the foliage, which are, prior to the death of the bulb, associated with attack by this pest. Certain other nematodes are sometimes responsible for somewhat similar injury to the bulbs, and in 1932 Steiner & Buhrer published a short account of those nematodes which have, on occasion, been found within and apparently been responsible for the diseased condition of narcissus bulbs in U.S.A.

More recently Goodey (1935) has described and named a new species of nematode which, as will be shown here, causes severe injury to narcissi. The description was based principally upon material supplied by the present writers, whose purpose here is to give such information as is available concerning the incidence and economic importance of the pest. Unfortunately the account is less complete than could be desired, but the pressure of other duties has prohibited the undertaking of more exhaustive studies. While at present the recorded cases of the incidence of the pest are very limited it is unquestionably potentially of major importance. At the outset it was thought that perhaps the failure to observe the pest previously was due to its inability to thrive except under the mild climatic conditions and relatively high soil temperatures pertaining to Scilly. That this is not the case is amply proven by the fact that it has flourished under normal outdoor conditions for the past two years at Reading.

Records of Occurrence.

With one exception, to be referred to below, the nematode has only been found in the Isles of Scilly. In these Islands it appears to be confined entirely to one variety of bulb namely, Narcissus Sir Watkin, a widely grown and important commercial variety. The stock of bulbs in

which it was first found had been introduced into the island of Bryher in or before the year 1895. This stock as far as can be ascertained gave no obvious cause for complaint until 1931, in which year it was realised that " eelworm " was present. That infection may have been present much earlier is suggested by local knowledge to the effect that Sir Watkin was sometimes unsatisfactory on land in which other varieties of narcissi could be grown successfully. Also it may be noted that bulbs concerned in these earlier records had never been subjected to the hot-water treatment. Bulbs emanating from this original introduction have in the last ten years or so been distributed generally through the islands, and these have in several instances on examination been found to be infested with the nematode.

The second series of records of occurrence relate to a stock, also of the variety Sir Watkin introduced from Holland to the island of St. Martins in the year 1928. It is perhaps possible that infection took place subsequently to the introduction, although a review of the attendant circumstances fails to reveal a likelihood of this being the case. In actual fact these bulbs have been moved three times since their original introduction. One portion was observed to be weak whilst growing in the second position. If this was due, as may well be the case, to nematode infection it would account for the general incidence throughout the stock as observed in 1935. Nevertheless it has not so far been possible to obtain any evidence that the nematode is actually present in the Dutch bulb fields.

The third and final record relates to the discovery by Staniland as related by Goodey (loc. cit.) of the nematode in narcissus bulbs variety Emperor at Seale-Hayne College, Devon. The bulbs concerned had been grown in the experimental plots of the College for some years, and had in that time been hot water treated at least once. The nematode was not detected in the main stock of bulbs, but only in isolated plants grown after strawberries which had themselves been infested by the closely allied nematode, *A. fragariae*. In view of this it is perhaps desirable to stress the fact that the nematodes within the bulbs were definitely identified as *A. hodsoni* by Goodey. From whence this infestation originated must remain a matter of conjecture. As an hypothesis it may be suggested that bulbs from Scilly had been grown in adjacent land at a fairly recent date and in these infection, eventually passed on to the Emperor bulbs, may have gone undetected.

Varietal Susceptibility in Narcissus.

The recorded incidence of the nematode in Scilly suggests its marked preference for the variety Sir Watkin, an impression strengthened by critical examination in the field. It is found that the trouble is most apparent in wetter situations. Further when certain varieties of narcissus, notably Soleil d'Or, but also in one instance M. J. Berkeley, are substituted for Sir Watkin in such land they flourish unharmed, despite the fact that " rogue " Sir Watkin left behind by accident continue infested. In passing it may be noted that Soleil d'Or is highly susceptible to attack by *Anguillulina dipsaci*.

An endeavour has been made to throw some light on this phenomenon. (The experiments have been carried out in the cement drain pipes, sunk vertically in the soil, which have proved eminently satisfactory when working with other plant parasitic nematodes.) Adequate quantities of bulbs have been available and the experiments have been replicated and repeated.

Throughout the trials infestation has persisted in the originally infected Sir Watkin bulbs, while previously clean bulbs of the variety have, on exposure to infection, soon been attacked by the nematodes.

In the main Soleil d'Or bulbs have proved very highly resistant to infection. In several cylinders they have remained entirely nematode-free over two complete growing seasons. In a few instances it has been possible to recover a few nematodes from the neck region of individual bulbs, but previous experience has shown (Hodson, 1931) that this is no definite indication that they would eventually become established within the plants.

In one instance Soleil d'Or bulbs were entered and the nematodes became at least temporarily well established. This record relates to one batch of bulbs planted rather shallow in November 1933. In early spring the bulbs were badly frosted, many were killed outright, and in September 1934 an examination of the survivors, which contained much tissue killed by frost, disclosed the presence of many of the nematodes, all stages including eggs then being present.

The foregoing observations are in the opinion of the writers sufficiently complete to suggest that under conditions favourable to normal healthy

growth Soleil d'Or, probably other closely related polyanthus varieties, and possibly some trumpet daffodils, are resistant to infection by this nematode. In fact, in the field it appears unlikely that infection would spread to them even if they were grown immediately after infested Sir Watkin bulbs. This possibility of substituting suitable varieties on infested land is of no little importance in districts such as Scilly. Here the range of available varieties of narcissus suitable for the early market is strictly limited, whilst at the same time it is often well nigh impossible to find further land on which the crop may be grown satisfactorily.

Nevertheless the recorded instance of the nematode's occurrence in Devon must be kept in view. It illustrates that the pest can flourish in the variety Emperor, which itself is very closely related to several other commercial varieties. It is therefore most desirable that further information be obtained as to the incidence and host range of the nematode.

Symptoms of Attack.

(a) *In foliage and flower stem.*

Leaves and flower stems of attacked plants are of a lighter green, ranging to yellow as opposed to the deep green of normal plants. The leaves are somewhat brittle in their basal regions, individual leaves may be dwarfed and sometimes split. There is no swelling, distortion or formation of " spikkels " so typical of attack by *A. dipsaci*. Occasionally blind flower buds are produced. Usually the plants flower but flowers are small, pale in colour and poor in form as compared with those from healthy plants. The foliage matures early and dies off quickly in the summer. In short, the general behaviour suggests lack of vigour but presents no really diagnostic symptoms. Microscopic examination of portions of the more yellow leaves, teased out in water, discloses the nematodes, sometimes in vast numbers, in all stages of development from egg to adult.

(b) *Within the Bulb.* Plate, fig. 1.

If an attacked bulb be cut through the centre in a horizontal plane areas of discoloured tissue will be found. These areas are packed with nematodes, are greyish in colour, and do not tend to occur in concentric rings to so marked an extent as in an attack by *A. dipsaci*.

Externally an infested bulb, particularly when dried off, shows marked symptoms of attack. (See Plate, fig. 2). The outer scales are exceedingly wrinkled, thin, paper-like and brittle, and of an unusual greyish colour.

This description holds good both for bulbs grown in Scilly and for those grown at Reading under an entirely different environment as to both soil texture and temperature and to climate.

The Effects of Attack upon the Plant.

Infested bulbs when left out of the ground for any considerable length of time at normal summer air temperatures deteriorate rapidly and may succumb to the attack. In the ground infestation does not usually bring about the death of the bulb, although upon occasion this has occurred in very wet situations.

The symptoms above ground, as indicated earlier, are marked yellowing, general unthriftiness and premature dying down. The most marked feature of infestation is the lack of increase in the stock, for while in most situations the numbers of bulbs do not actually dwindle they do not increase at a normal rate, very little increased weight of bulbs being obtained when lifting two seasons after planting.

An attempt has been made, by means of a small experiment carried out at Reading, to assess the actual depressing effects attending infestation by the nematode.

Three batches, A B C each consisting of 24 individual infested bulbs, variety Sir Watkin, were selected, weighed and planted on November 1st, 1933. Each batch weighed 31 ozs. A and C were lifted in August 1934 and after drying weighed respectively 32 ozs. and 33 ozs. C was hot water treated for 3 hours at 110°F. and both batches replanted in September 1934. A, B and C were lifted in August 1935 and after drying A weighed 34 ozs., B, which had been undisturbed in the soil for 2 seasons 36·5 ozs., and C, one year after hot water treatment 47 ozs., thus gaining no less than 14 ozs. in twelve months once the nematodes were destroyed.

In considering the above figures it is interesting to note that 24 bulbs were picked from a further infested sample of bulbs received from Scilly in September 1935. These weighed 30 ozs. As opposed to this 24 bulbs grown at Reading under similar conditions to those used in the experiment, but which themselves had never been attacked by the nematode, weighed no less than 65 ozs.

The figures suggest plainly that infestation by *S. hodsoni* has an extremely marked depressing effect upon the bulbs. A somewhat surprising feature is that despite heavy infestation the bulbs as a general rule manage to survive indefinitely under normal cultural conditions.

Practical Considerations.

The nematodes are effectively destroyed by the hot water treatment as practised for the control of *Anguillulina dipsaci*. Clearly infected stocks should be bathed and replanted in clean land. There arises a very real danger of losing quantities of bulbs if these for any reason are held long in store during the summer months. If infected bulbs are lifted they should, prior to bathing, be kept in as cool a situation as is available. Further danger arises whilst the bulbs are in the ground in that the presence of damaged tissues within them invites invasion by other destructive organisms. No information is available as to how long land is likely to remain infective. Three years between plantings is usually considered adequate. A shorter period would probably suffice, provided always that all rogues are removed during the first vacant season.

Should it be essential to replant at once with narcissus it would appear to be reasonably safe to restock with a polyanthus variety, particularly Soleil d'Or. But further information as to varietal susceptibility is needed. Also, as the origin of these infestations is obscure an endeavour should be made to examine closely plants other than narcissus in the vicinity of an attack with a view to finding an alternative host.

Finally, the behaviour of the nematode at Reading over more than one year indicates that there is no bar to its flourishing in less favoured climates than those experienced in the extreme South West of these islands. It might therefore be of advantage to watch carefully for its incidence both in this country and in the Dutch bulb fields.

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External appearance of dormant bulbs of narcissus Sir Watkin, on left infested by *Aphelenchoides hodsoni*, on right healthy (somewhat reduced).

Transverse section through bulb of narcissus Sir Watkin, showing discoloured areas infested by *Aphelenchoides hodsoni* (somewhat enlarged).

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 99–100.

The Correlation between the Worm-burden and Live-weight Increase of Grazing Sheep.

By A. H. H. Fraser[1], D. Robertson[2] and J. E. Ritchie[3].

Variability in the number of intestinal worms found at autopsy in individual sheep of the same flock is extremely wide. Thus, Fraser & Robertson (1933), put 32 parasite-free lambs to graze on heavily sheeped pasture for 45 days. Sixteen of the lambs were well fed, sixteen were poorly fed and all were slaughtered at the end of the 46-day grazing period. The number of *Haemonchus contortus* present in the contents of the abomasum of each lamb was counted. The range of variation in the number of *Haemonchus* found was from 0 to 222 in the poorly fed group and from 2 to 76 in the well-fed group.

A recent experiment by the same workers on the effect of salting pasture on the incidence of stomach worms in sheep revealed a similar variability in the number of worms found. Thirty-one parasite free lambs were grazed on heavily sheeped pasture for a period of 50 days and were then slaughtered. The species of worms counted were *Haemonchus contortus*, *Ostertagia* spp., and *Trichostrongylus axei*. The total number of worms in the abomasums of the lambs varied from 118 to 1,050.

In seeking for possible causes for this variation it was observed that there appeared to be a correlation between the total number of worms found at autopsy and the live-weight increase of the lambs during the grazing period. The detailed figures—index number of lamb, number of worms, and weight increment are shown in Table I.

From the data (Table 1) the correlation coefficient, measuring the relationship between total number of worms and weight increase of lamb, was found to be $+0{\cdot}613$. On applying the relevant statistical test, for a group of the size we have studied, it was found that the positive correlation was significant.

This result shows that one cause of the variability of worm-burden in lambs of the same flock and on the same pasture is that those lambs which

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are gaining weight most rapidly tend to contain the greatest number of worms. The most probable reason for this correlation seems to be that the most thriving lambs eat more grass and consequently ingest more larval worms.

TABLE I.

Number of lamb.	Number of total worms.	Weight increment of lamb during grazing period.
44	227	+ 5·0 lbs.
46	611	+ 0·0 ,,
47	871	+ 3·5 ,,
50	393	+ 0·5 ,,
51	249	+ 0·75 ,,
53	415	+ 1·25 ,,
64	580	+ 4·50 ,,
65	259	− 1·75 ,,
66	456	+ 6·0 ,,
67	537	+ 4·0 ,,
69	318	+ 2·75 ,,
74	562	+ 5·0 ,,
76	484	+ 7·75 ,,
79	536	+10·25 ,,
80	751	+ 6·75 ,,
82	596	+ 6·50 ,,
45	236	+ 2·25 ,,
52	575	+ 7·25 ,,
55	248	+ 2·75 ,,
56	629	+ 9·5 ,,
57	714	+ 8·5 ,,
59	212	+ 5·75 ,,
60	1,050	+10·25 ,,
61	795	+12·25 ,,
63	364	+ 0·75 ,,
70	484	+ 6·5 ,,
72	118	+ 3·5 ,,
73	174	+ 1·25 ,,
77	381	+ 8·75 ,,
71	826	+15·5 ,,
83	510	+ 6·75 ,,

SUMMARY.

There is a definitely significant correlation between the worm-burden and the live-weight increase of grazing sheep.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 101–106.

The Effect of Salting Pasture on the Incidence of Stomach Worms in Sheep.

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Introduction.

As a result of a recent survey of Scottish sheep it has been found that *Ostertagia circumcincta* is the parasitic helminth of widest distribution and greatest pathogenic significance. Probably because of its small size and the protection it receives from mucus of the stomach wall this species is relatively resistant to the action of anthelmintic drugs which are consequently of but little use in its control. It therefore seemed useful to explore other methods of reducing the incidence of *Ostertagia* among grazing sheep.

Mönnig (1931) discussing the artificial infestation of sheep with larval cultures of parasitic worms stated " During this time it is advantageous to give little concentrated food and no salt to sheep." Mönnig's observation suggested the possibility of opposing a natural infestation by providing abundant salt in the sheep's diet. Moreover in reply to our questionnaire issued to Scottish farmers, several replies stated that salting of sheep pastures was the method of control adopted. Again, there is the well-known capacity of salt marshes to carry heavy stocks of sheep without the appearance of parasitic disease.

In view of this suggestive evidence an experiment was undertaken in which two groups of lambs, initially parasite-free, would be exposed to a natural infestation on heavily sheeped pasture, one group of lambs to be confined to salted pasture, the other to pasture of similar grazing value but unsalted.

Experimental Procedure.

The method of rearing parasite free lambs was that previously described by us (1933). Faecal examination showed that the lambs were, in fact, parasite free.

On 29th August the lambs were put out on to fenced-in poultry runs which had been heavily sheeped during the summer. Four of these runs had been previously salted on the 22nd August with 5 cwt. per run of 1,080 sq. yards, or roughly one ton to the acre.

The lambs were divided into two groups, one of seventeen, the other sixteen. The first group of seventeen were kept throughout the experiment on runs which had been salted first at the rate of 1 ton, later of 10 cwt. to the acre. The second group of sixteen lambs were kept on similar but unsalted runs.

Owing to the dry weather the growth of grass on the runs was not so plentiful as expected, and concentrates had to be fed at the rate of $\frac{3}{4}$ lb. per head per day. Both groups received exactly the same kind and quantity of concentrates. Both groups of lambs gained weight while on pasture. The group on salted pasture averaged 51·6 lbs. at the beginning of the grazing period and 55·7 lbs. at its conclusion—a gain of 4·1 lbs. in 50 days. The group on unsalted pasture averaged 51·0 lbs. at the beginning of the grazing period and 57·8 lbs. at its conclusion—a gain of 7·8 lbs. in 50 days. The group on unsalted pasture thus appear to have done better although the individual variation in live-weight gain in both groups was wide, varying from a loss of 1·75 lbs. to a gain of 10·25 lbs. in the salted group, and from a gain of 0·75 lbs. to one of 15·5 lbs. in the unsalted group. In the latter group there is a significant correlation between the individual gain in live-weight of the lambs and the total number of worms their stomachs were found to contain. This result is of importance in helping to explain the wide variation in the worm-burden of individual lambs on the same pasture and will form the subject of a later communication.

The salt burned the grass rather badly so that the group on salted pasture actually covered more ground during the experiment than the group on unsalted pasture. During the grazing period the group on salted pasture grazed nine runs each of 1,080 sq. yds. and the group on unsalted pasture grazed 6 runs of 1,080 sq. yds. After 50 days grazing the lambs were slaughtered and the abomasums immediately removed to the laboratory. Through accident two abomasums were rendered useless.

Technique.

The contents of each abomasum was everted into a preserving jar and the abomasums afterwards opened from end to end in a flat enamelled

tray. The mucosa was washed with a small quantity of hot water and the washings added to the contents in the jar. This washing was repeated three times to ensure that the mucosa was free from worms. Finally formalin was added and the jar stored for future examination.

Isolation of the worms was accomplished by the simple process of sedimentation as follows: The contents of each jar were emptied into a large glass cylinder of approximately 4,000 c.c. capacity and the material and worms allowed to sediment for a period of 15–30 minutes. In several cases the ingesta was inclined to rise to the surface but on stirring the surface lightly the material gradually fell to the bottom. The supernatant fluid was then poured off and the process repeated several times until the material was free of colouring matter.

The next step consisted in isolating the various species of worms.

In view of the ease with which *Haemonchus contortus* can be recognised, it was decided to examine the whole of the material. This was accomplished by examining it in small portions in a black photographic dish to which sufficient water had been added to free the worms from the undigested food. The *Haemonchus* were then picked out with a forceps and counted.

With regard to *Ostertagia* spp. and *Trichostrongylus axei* representative samples of the ingesta were taken. The material was poured into a 2,000 c.c. cylindrical jar and filled to the 2,000 c.c. mark. The mixture was vigorously stirred with a 100 c.c. wide bored pipette and 100 c.c. of the whole drawn off from various depths in the jar as the pipette was gradually raised from the bottom to the top of the jar. The sample was examined as in the case of *Haemonchus* in small portions of about 10 c.c. with the addition of 100 c.c. of water. The worms were then isolated with a finely pointed needle.

Naturally this method is liable to some degree of error and in order to increase the efficiency of the method a second 100 c.c. sample was drawn off and the worms similarly counted. In most cases the counts from the duplicate samples showed a close correspondence. The total numbers of *Ostertagia* and *Trichostrongylus* were obtained by taking the average of the two counts and multiplying by 20.

Of the species of *Ostertagia*, *O. circumcincta* occurred much more frequently than *O. trifurcata* but no attempt was made to separate the two species.

TABLE I.

The Effect of Salting Pastures on the Worm Burden of Sheep.
Results of Worm Counts.

Pastures Salted.

Rowett No. of lamb.	No. of *Haemonchus contortus.*	No. of *Ostertagia* spp.	No. of *Trichostrongylus axei.*
44	9	198	20
46	11	180	420
47	11	460	400
50	3	230	160
51	9	180	60
53	25	290	100
64	0	60	520
65	50	209	0
66	46	230	180
67	37	240	260
69	8	270	140
74	22	480	60
76	4	380	100
79	16	460	60
80	11	60	680
82	6	190	400
Total ...	268	4,117	3,560
Av. No. of Worms per lamb ...	17	257	223

Pastures not Salted.

45	56	180	0
52	5	310	260
55	58	190	0
56	19	490	120
57	24	220	470
59	12	140	60
60	40	490	520
61	15	100	680
63	94	200	70
70	44	330	110
72	18	20	80
73	34	120	20
77	81	240	60
81	96	710	20
83	30	330	150
Total ...	626	4,070	2,620
Av. No. of Worms per Lamb ...	42	271	175

Results.

The average number of stomach worms found in the group of sheep on unsalted pasture was 488, while in the group on salted pasture the average number was 497. The difference between the two average values is quite small and is statistically not significant so that the present experiment suggests that the salting of pasture is not effective in reducing the worm-burden of sheep.

Only in infestation of *Haemonchus contortus* does salting of pasture appear to have reduced the worm count. In the "unsalted" group the average number found was 42, while in the "salted" group it was 17. This difference of 25 was found to be statistically significant, in other words, such a difference is unlikely to occur at random between two groups of the size used in the present experiment if *both* groups were grazed on salted *or* on unsalted pasture.

In the case of *Ostertagia* spp. the average numbers were 271 and 257 in the "unsalted" and "salted" groups respectively. The difference between these average numbers is not statistically significant and could quite readily occur from groups submitted to the same treatment.

Trichostrongylus axei was found in unusual and unexpected abundance. The average number was 175 in the "unsalted" group as against 223 in the "salted" group. The average number was thus actually higher in the group of sheep on salted pasture, but again the difference is not significant and might occur at random from two groups grazing under identical conditions.

Taking all the figures into consideration it is quite evident that salting pasture does not give promise as a method of controlling *Ostertagia* infestation. The discrepancy between the results as regards *Haemonchus* and those of *Ostertagia* and *Trichostrongylus* is difficult to explain, and no satisfactory explanation can be offered. But even supposing *Haemonchus* to be especially sensitive to salt the result is not of practical importance, since satisfactory methods of controlling *Haemonchus* are already known.

The detailed figures of the worm counts are shown in Table I.

Discussion.

In view of the resistance of larval Helminths to environmental conditions, it is improbable that salting pasture could have a direct lethal effect. It seemed possible, however, that the continued ingestion of salt

by the grazing sheep might inhibit the development of the larvae within the sheep's stomach. The results of this experiment does not suggest that such an effect occurs except possibly in the case of *Haemonchus*. It is possible that a more direct feeding of salt as for example mixed with concentrate feed might have had a more marked effect.

Summary.

1. Salting of pasture was explored as a means of controlling stomach worm infestation of grazing sheep.

2. Infestation with *Haemonchus contortus* was significantly decreased, but that with *Ostertagia* spp. and *Trichostrongylus axei* was not significantly affected.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 107–112.

On *Anguillulina oryzae* (v. Breda de Haan, 1902) Goodey, 1932, a nematode parasite of the roots of Rice, *Oryza sativa* L.

By T. Goodey, D.Sc.

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Introduction.

The identity and status of the nematode described by van Breda de Haan (1902) from the roots of diseased rice plants in the Dutch East Indies under the name of *Tylenchus oryzae* have remained more or less conjectural owing to the inadequacy of the original description and the absence of any drawings showing its appearance and structure. The present writer was so doubtful of its validity as a species that in his monograph on the genus *Anguillulina* (1932) he listed it under "species inquirendae." In April 1934, Dr. J. van der Vecht of the Institute of Plant Diseases, Buitenzorg, Java, visited this Institute and in the course of conversation informed the writer that in his opinion the species was a valid and distinct one. He kindly promised that on his return to Buitenzorg he would collect specimens of the parasite and forward them for examination. In due course a good number of adult specimens, preserved in 5% formalin, were received and on these it has been possible to base the observations embodied in the following pages. The writer desires to express his thanks to Dr. P. van der Goot, Director of the Institute of Plant Diseases, Buitenzorg and to Dr. van der Vecht for their kindness in making this interesting material available for investigation.

Before proceeding with the description of the parasite it may be stated that in addition to the nematodes from rice roots, a number of other parasitic and free-living eelworms were received. Perhaps the most interesting of these is *Anguillulina similis* (Cobb), the "burrowing nematode," from the roots of *Piper nigrum* L. (black pepper) and *Piper Cubeba* L. (cubebs). Both of these plants are previously unrecorded hosts of this parasite the former, according to Dr. van der Vecht, being very severely attacked in the island of Bangka, Dutch East Indies.

Anguillulina oryzæ.

Dimensions :—*Female*, length, 1·2 mm. to 1·6 mm., α=49–65, β=4·5–5·7, γ=14·7–19·3, V=50% to 56·6% ; *male*, length, 1·08 mm. to 1·307 mm., α=43–65, β=4·2–5·3, γ=13·5–16·8, spicules, 25μ–28μ, gubernaculum, 9μ–10μ, buccal spear, 18μ–19μ.

Morphology. Body very slender, in both sexes being from 50 to 60 times as long as wide. Tapering a little anteriorly and posteriorly, the tail in both sexes being provided with a minute terminal process. Cuticle transversely striated. Lateral fields about one-third the width of the body, each made up of two outer areas and an inner one all of about the same width. Head in the form of a flattened hemisphere, not off set by constriction. Under high magnification, seen to be supported by a strong cuticular framework of the usual type dividing the head into six radial segments. Buccal cavity tubular with rounded thickenings at base. Outer supports of head framework sickle-shaped, joining head to body. Faint backward prolongations of buccal cavity to form spear guide. Spear of usual type, basal swellings comparatively large and rounded. Oesophagus as far as muscular bulb typical ; bulb with three cresentic thickenings of lining. Outlet of dorsal oesophageal gland just behind base of spear. Nerve ring crossing isthmus of oesophagus. Excretory pore slightly posterior to nerve ring. Glandular portion of oesophagus comparatively long and extending ventro-laterally to anterior region of intestine. Actual connection of intestine with post-bulbar portion of oesophagus rather obscure but from an examination of several specimens in lateral and dorsal aspect under high magnification, it appears that the isthmus, just after being crossed by the nerve ring, divides, giving off the glandular part ventrally and the beginning of the intestine dorsally. The three oesophageal glands are continued ventrally and end at about one-fifth to one-quarter of the body length from the anterior end of the body. The three nuclei of the glands can also be fairly easily distinguished toward the swollen end of this region. In most of the examples examined the intestine did not occupy the full width of the body and was but sparsely stocked with fat globules.

Female. Vulva equatorial or a little post-equatorial in position. Gonads paired, opposed and outstretched ; comparatively short, the ovaries reaching rather more than one-third the distance from vulva to

Anguillulina oryzae (v. Breda de Haan).

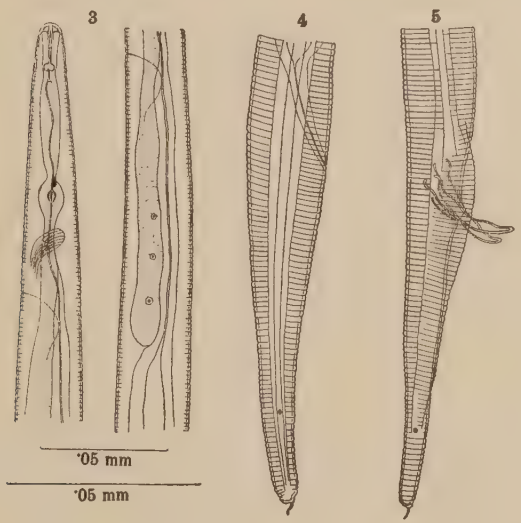
Figs. 1 & 2. Adult female and male, respectively under low magnification, showing general shape and structure.

head and tail respectively. This may have been due to the fact that none of the females examined appeared to possess ovaries in a fully mature condition. Tail tapering gradually to terminus which is bluntly conical and carries a fine terminal process. The lateral fields reach almost to the end of the tail and a very small lateral caudal papilla is present on each side of the tail in the centre of the lateral field at one-third to one-quarter of the tail length from the tip.

Male. Gonad single, outstretched and extending about one-third of the body length anteriorily. Testis narrow, apparently not reflexed. Vas deferens wider, making up about one-half the whole gonad and containing numerous small round sperms. Ductus ejaculatorious narrow. Tail tapering gently to terminus which is somewhat variable in outline, sometimes rather conical and sometimes rather blunt; in all cases carrying a small terminal process placed somewhat ventrally. The lateral fields widen out on reaching the beginning of the bursa. Outer areas of field bear markings at first regularly and then irregularly spaced relative to the transverse striae of the body. The ventral outer area extends but a short distance on the ventral side of the bursal wing; the dorsal area to a little short of level of cloacal opening. Bursal alae rather narrow; widest opposite cloaca, then narrowing and joining cuticle of body at one-quarter to one-third the length of the tail from its end. There is a very small caudal papilla on each side of the tail corresponding in position to the lateral caudal papillae of the female. Bursal wings striated, edges slightly crenate. Striae crossing most of wing as far as backward extension of outer line of lateral field. Spicules slightly arcuate, anterior ends cephalated by constriction, shaft swelling a little in middle region and then tapering to point. Gubernaculum simple, about one-third the length of the spicules.

Systematics. Among the numerous species of the genus *Anguillulina* the only one which calls for some discussion in relation to *A. oryzae* is *A. papillata* (Imamura, 1931) Goodey, 1932. This species was found in soil of a paddy field at Komaba, Tokyo, Japan. Adults of both sexes have practically the same length as those of *A. oryzae*; the females being 0·93 mm. to 1·5 mm. and the males 1·02 mm. to 1·32 mm. long as compared with 1·2 mm. to 1·6 mm. and 1·08 mm. to 1·307 mm., given above, for the females and males respectively of *A. oryzae*. The body also of *A. papillata* has the same degree of slenderness as *A. oryzae*; the

proportion varying from 50–60 for females and 52·8–53·7 for males as compared with 49–65 for females and 43–65 for males in *A. oryzae*. The vulva is slightly post-equatorial in *A. papillata* as in *A. oryzae*. The most striking resemblance, however, is that shown by the male tail with its minute terminal process. Imamura's fig. 26*c* is remarkably similar to the tail of *A. oryzae* as seen under moderately low magnification. The



Anguillulina oryzae (v. Breda de Haan).

Fig. 3. Head end and oesophageal region in lateral view, highly magnified.

Figs. 4 & 5. Female and male tails in lateral view, highly magnified. The upper scale applies to fig. 3, and the lower one to figs. 4 and 5.

contour of the tapering post-anal region, the disposition of the bursal wings and the shape of the terminus being identical in both. Imamura said that in *A. apapillata* there were no bursal papillae whereas the writer has found in *A. oryzae* a minute papilla on each side of the tail where the bursal wings join the body posteriorly. Had papillae been present on the tail of the worms described by Imamura the writer would have had no

hesitation in claiming that the two forms are identical. It is consequently suggested that if on re-examination the tails of both sexes of *A. apapillata* are found to reveal the presence of minute papillae, in the position they occupy in *A. oryzae*, the identity of the two species would be established and as a result *A. apapillata* (Imamura, 1931) would become a synonym of *A. oryzae* (v. Breda de Haan, 1902). In this connection the fact that the worms described by Imamura came from soil of a paddy field is worthy of consideration in connection with the probable identity of the two forms.

Bionomics. The writer is not in a position to give any particulars on the life-history of the parasite or on the symptoms and pathology of its attack on rice roots. Van Breda de Haan considered that it was the cause of the disease of rice known as "Omo Mentek" but subsequently this disease has come to be looked upon as not caused by eelworms. There can be no doubt, however, that *A. oryzae* lives parasitically in the roots of rice. Dr. van der Vecht has informed the writer that infection experiments with it on rice gave positive results. He is of the opinion, however, that the damage caused to the host is not of serious importance.

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 113–118.

On *Schwartziella*, a new nematode Genus for *Cooperia nodulosa* Schwartz, 1928.

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During the study of the telamon of various species of Cooperias collected from domesticated and wild ruminants in South Africa and from domesticated ruminants in Great Britain, it was observed that *Cooperia serrata* Mönnig, 1931 had no telamon and that it also differed from the other members of the genus in other respects.

Schwartz (1928) described *Cooperia nodulosa*. The specimens were collected from nodules in the mucosa of the small intestine of a carabao (*Bubalis bubalis*) in the Philippine Islands.

Mönnig (1931) described *Cooperia serrata* from a springbuck (*Antidorcas marsupialis*) in the Union of South Africa. He infected lambs by feeding infective stage larvae to them. Mönnig, in his description of the species points out that the dorsal ray and the spicules of his species are very similar to those of *Cooperia nodulosa* Schwartz, 1928 but differs from the last mentioned in that the spicules have only 4 to 5 dentate processes on the dorso-medial arm instead of 7 as recorded in Schwartz's species.

Daubney (1933) records *Cooperia serrata* from sheep in Kenya Colony and figures the spicule with seven distinct dentate processes.

The specimens which were examined by me showed the presence of 5 to 6 distinct processes. The various measurements quoted by Schwartz, Mönnig and Daubney agree with the corresponding measurements in the

specimens examined by me and it would appear that *Cooperia serrata* Mönnig, 1931 may be identical with *Cooperia nodulosa* Schwartz, 1928.

Daubney (1933) in his discussion of *C. serrata* expressed the view that this species is not a typical member of the genus *Cooperia* because cervical and prebursal papillae are not present in the other members of the genus. This is not correct. Cervical and prebursal papillae are described for *Cooperia surnabada* Antipin, 1931, and are present in specimens of *C. curticei*, *C. oncophora* and *C. surnabada* (= *C. macmasteri*) from sheep and cattle in Great Britain and in *C. pectinata*, *C. punctata*, *C. hungi*, *C. neitzi* and must be present in *C. africana* for which Mönnig (1935) records them as absent.

The cervical and prebursal papillae are well developed in *C. serrata* but very poorly developed in those species of *Cooperia* in which the telamon is present.

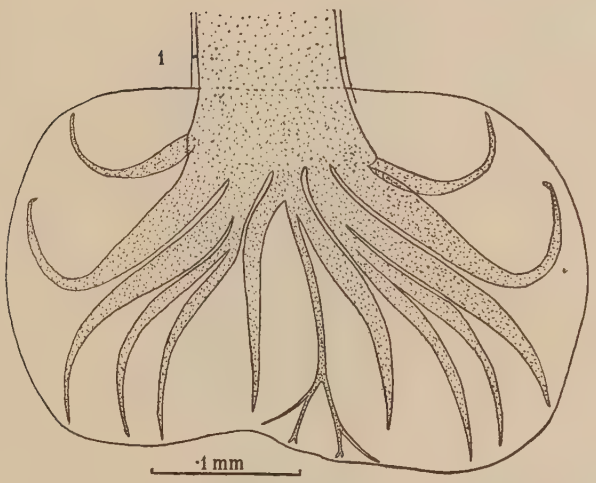
The dorsal ray of *C. serrata* seems identical with that figured for *C. nodulosa*. Mönnig (1931) describes the dorsal ray as follows :—" The dorsal ray branches distally, each branch again dividing into a short, median, bidigitate branch and a lateral, rather slender branch which is directed postero-laterally. In this respect this species shows much similarity to *C. nodulosa* Schwartz, 1928." Daubney (1933) describes this structure as follows :—" The dorsal ray is long and slender and is divided in its distal fourth. The terminal branches form a roughly lyre-shaped structure and in turn they are bifurcate at their tips. Each terminal branch has a slender twig which springs from the arched portion of the branch, and is directed laterally with a tendency to bend ventrally."

In the specimens examined by me the dorsal ray is as figured (fig. 1).

Schwartz (1928) described the dorsal ray as follows :—" . . . the dorsal ray bifurcates, each terminal branch ending in two blunt digitate processes ; each terminal stem of the dorsal ray gives off a branch in its posterior portion having a more or less horizontal direction along the transverse axis of the worm."

Because *C. serrata* differs from the other members of the genus in having no telamon and in that its spicules and the arrangement of its bursal rays are rather atypical from those of the type species of the genus *Cooperia*

Ransom, 1907, I propose the new genus *Schwartziella* in honour of Dr. Benjamin Schwartz and designate *Schwartziella nodulosa* (Schwartz, 1928) as type of the genus.



Schwartziella serrata.

Fig. 1. Dorsal view of bursa.

SCHWARTZIELLA n. g.

Diagnosis.—Trichostrongylidae: Relatively small worms. Head rounded without well marked lips or conspicuous circumoral papillae.

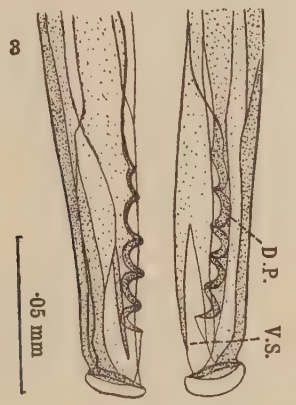
Cephalic extremity with cuticular inflation with well marked transverse striations. Cuticle of remainder of body with prominent longitudinal ridges. Faint transverse striations present between the ridges. The ridges are perpendicularly striated and the striations correspond to the number of faint transverse striations on the cuticle. Cervical and pre-bursal papillae present in the males. Cervical and caudal papillae present in the females. Buccal cavity small and indefinite. Copulatory bursa voluminous and not divided into distinct dorsal and lateral lobes. Inner

Schwartziella serrata.

Fig. 2. Spicules.

surface of bursa bears fine dentations. Bursal rays well developed and grouped into three lots—ventrals, laterals and dorsals. Ventro-ventral ray distinctly more slender than the latero-ventral and diverging. Latero-ventral thicker than the externo-lateral which is the next in thickness. Medio-lateral slightly more slender than postero-lateral. All the lateral rays are directed laterally and posteriorly and end near the edge of the bursa. Externo-dorsals relatively stout rays, arising from a common stem with the dorsal. The left externo-dorsal arise before the right externo-dorsal. They are the third thickest pair of rays. Dorsal ray,

with a stem in common with the right enterno-dorsal, is long, slender and bifurcates about its posterior third into two branches of which the left branch bifurcates sooner than the right into a short medial branch and a longer lateral (or ventral) branch. The medial branch is distally bluntly bidigitate. The lateral (or ventral) branch is long and slender and passes postero-laterally to end near the edge of the bursa. Spicules identical, relatively stout, massive in appearance, brown in colour, well chitinised, armed with a ventro-medial spine and a stout dorso-medial



Schwartziella serrata.

Fig. 3. Caudal extremities of spicules showing the ventro-medial spine (v.s.) and the dentations on dorso-medial process (d.p.).

process with dentations dorsally. Alae and alar expansions present on spicules. Gubernaculum or telamon absent. Vulva covered with a linguiform flap and in the posterior quarter of the worm. Caudal extremity of female long and tapering to end in a thin process.

Parasites of ruminants.

Type species: *Schwartziella nodulosa* (Schwartz, 1928).

Other species: *Schwartziella serrata* (Mönnig, 1931).

Schwartziella serrata is evidently very closely related to, if not identical with, the type species.

Measurements (in millimetres) of *S. nodulosa* and *S. serrata*.

Species	*S. nodulosa* ...	*S. serrata*	*S. serrata*
Authors	Schartz (1928) ...	Mönnig (1931)	Daubney (1933)
Hosts	*Bubalis bubalis*	Springbuck	Sheep
Habitat	In nodules in small intestine	Small intestine	Small intestine
Locality	Philippine Islands	S. Africa	Kenya
Length of body ♂	7·2	6·9–7·8	5–6
,, ,, ♀	11	8·8–10·3	7–10
Max. width of body ♂	0·218	0·106	0·120
,, ,, ♀	0·200	0·113	0·120
Diameter of cephalic inflation ♂	0·047–0·050	0·041	0·033–0·035
,, ,, ,, ♀	0·047–0·050	0·044	0·035–0·045
Length of Oesophagus ♂	under 0·500	0·386–0·500	0·34–0·40
,, ,, ♀	over 0·500	0·460–0·500	
Anterior extremity to excretory pore ♂	—	0·220	—
,, ,, ♀	—	0·320	—
Anterior extremity to cervical papillae ♂	—	0·260	—
,, ,, ♀	—	0·390	—
Anterior extremity to nerve ring ♂	—	0·193	—
,, ,, ♀	—	0·270	—
Length of spicules ...	0·304–0·320	0·259–0·270	—
Vulva to caudal end ...	2	1·77–2·05	1·25–1·75
Anus to caudal end ...	0·210	0·150	0·115–0·130
Ova—length	0·040–0·051	—	0·075
,, —width	0·031	—	0·040

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Journal of Helminthology, Vol. XIV, *No.* 2, *June*, 1936, *pp.* 119–126.

The occurrence of *Molineus patens* (Dujardin, 1845) in English Stoats and Weasels.

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As stoats and weasels are frequently trapped as vermin it is not surprising that the helminthological fauna has been examined by a number of workers. The following helminths have already been recorded as parasitizing the weasel, *Mustela nivalis*, and the stoat, *Mustela erminea*.

WEASEL.

Trematoda.

Euparyphium melis (Schrank, 1788).
Euryhelmis squamula (Rudolphi, 1819).
Clonorchis sinensis (Cobbold, 1875).

Cestoda.

Sparganum ellipticum Molin, 1858.
Taenia hydatigena Pallas, 1766.
Taenia intermedia Rudolphi, 1810.
Taenia mustelae Gmelin, 1790.
Taenia tenuicollis Rudolphi, 1819.

Nematoda.

Ascaris columnaris Leidy, 1856.
Capillaria mustelorum Cameron & Parnell, 1933.
Dioctophyme renale (Goeze, 1782).
Filaroides mustelarum (Rudolphi, 1819).
Molineus patens (Dujardin, 1845).
Strongyloides papillosus (Wedl, 1856).

STOAT.

Cestoda.

Taenia brevicollis Rudolphi, 1819.
Taenia hydatigena Pallas, 1766.
Taenia intermedia Rudolphi, 1810.
Taenia taeniaeformis Batsch, 1786.
Taenia tenuicollis Rudolphi, 1819.

Nematoda.

Ascaris columnaris Leidy, 1856.
Molineus patens (Dujardin, 1845).
Strongyloides mustelorum Cameron & Parnell, 1933.

In their extensive survey of the internal parasites of land mammals of Scotland, Cameron & Parnell (1933) state that although they had the opportunity of examining a large number of stoats and weasels from all parts of that country the only nematodes found by them in the stoat were a single female "*Trichostrongylus* sp." and a species of *Strongyloides* at Blair Atholl and a single male *Capillaria* in the stomach of a weasel.

During the spring of this year the opportunity was taken of examining 6 stoats and 9 weasels from Mimms Park in Hertfordshire. In all of them were found a number of specimens of *Molineus patens* in the stomach and intestine. In a weasel one male specimen of the genus *Capillaria* also occurred. This is provisionally identified as *C. mustelorum* (Cameron & Parnell, 1933).

Molineus patens has been recorded a number of times as a parasite of the genus *Mustela* on the Continent but never so far in Britain, unless the female "*Trichostrongylus* sp." of Cameron & Parnell proves to belong to this species. I take this opportunity therefore of recording the presence of this trichostrongyle in English stoats and weasels.

While identifying these worms several small points in their structure which had not been remarked upon in previous descriptions were noted. In fact, the general morphology does not seem to have been completely studied. Hence a more detailed description is made available now.

There was considerable variation in the overall measurements in the adult worms and there seems to be a tendency for worms recovered from the larger host, the stoat, to be of larger size than those recovered from the smaller weasel. The following description is based on specimens from the weasel.

Description.

The cuticle is longitudinally striated with 44–50 striations. It is finely transversely striated also. The cephalic inflation is distinct being about 0·09 mm. long and 0·06 mm. broad. The mouth capsule is rudimentary. The oesophagus tapers slightly anteriorly and has a small posterior bulb. The excretory pore is situated half way down the oesophagus where it

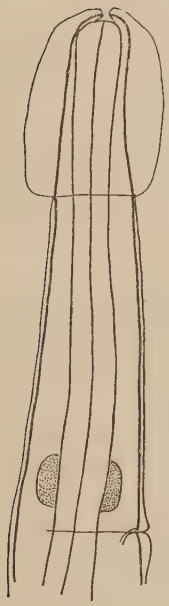

Fig. 1

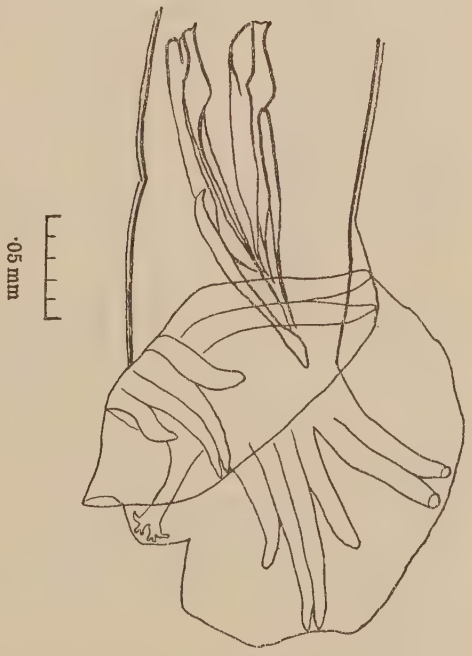

Fig. 2

Molineus patens.

Fig. 1. Latero-ventral view of male tail showing bursa and spicules.

Fig. 2. Anterior end showing cephalic inflation, nerve ring and excretory pore opening into the cervical groove.

opens into the cervical groove. The cervical groove extending for three-quarters of the circumference of the worm is absent from the dorsal surface. The nerve ring is just anterior to the position of the excretory pore. Two small cervical papillae are present opposite the nerve ring. (Fig. 1.)

The *Male* varies in length from 5·14 mm. to 7·14 mm. The bursa is lobed and covered internally with papillae. There are two large lateral lobes and a small dorsal lobe. The two ventral rays run parallel to one another, reaching the edge of the bursa, but are separated at their distal extremity. The three lateral rays are also parallel except for their extremities where divergence occurs; the antero-lateral ray stops 0·03 mm. short of the edge of the bursa, but the medio-lateral and postero-lateral rays reach the edge. The dorsal ray gives off the dorso-lateral rays almost perpendicularly near its base, these then run parallel to the lateral rays and terminate at the same level as the antero-lateral rays. The dorsal ray divides at its posterior extremity into two main branches each of which gives off a branch laterally and then divides into two, the inner one of which is slightly the longer.

There are two short brown spicules which are similar and measure about 0·15 mm. in length. Each spicule divides into two portions 0·03 mm. from the anterior extremity. The dorsal portion is appreciably broader than the ventral portion and tapers sharply to terminate with a fine point having a postero-ventral direction. The ventral portion divides into two forming medial and ventral parts. The medial part tapers rapidly to finish level with the point of the dorsal portion while the ventral part, which is narrower, extends to end in a sharp point 0·02 mm. beyond the extremity of the medial part. Hence each spicule is divided posteriorly into three sharp points one of which is appreciably longer than the other two. This I regard as the chief diagnostic feature of the species.

The gubernaculum, which measures 0·1 mm., lies dorsal to the spicules; its anterior extremity is sharply pointed in a ventral direction, the posterior extremity is spatular in shape when viewed dorso-ventrally.

The *Female* measures 6·8–11·5 mm. long. The vulva is situated approximately 1·8 mm. from the posterior extremity and is covered by a transverse vulvar flap. The anus is 0·09 mm. from the posterior

extremity which consists of a dorsally placed, sharply pointed process 0·01 mm. long. Ventral to the base of this caudal process are four inflations of cuticle (fig. 4) two to each side of the mid-ventral line. These two ventral inflations each contain a small papilla arising from

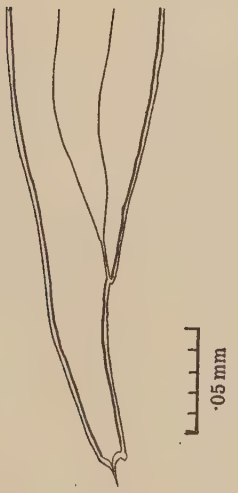

Fig. 3

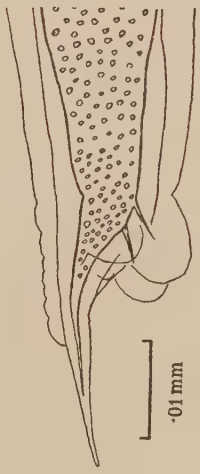

Fig. 4

Molineus patens

Fig. 3. Caudal extremity of female under low magnification.

Fig. 4. Female tail under higher magnification to illustrate the cuticular inflations, papillae and caudal process.

the body wall but not penetrating the cuticle. These structures I consider to be those described as a "papilla" by Dujardin and as two "papillae" by von Linstow.

The eggs are typical trichostrongyle eggs and those in the uterus nearest the vulva measure 0·065–0·07 mm. by 0·04–0·045 mm.

Affinities.

The chief characters of the genus *Molineus* (Cameron, 1923) appear to be :—

1. It belongs to the family Trichostrongylidae.
2. Spicules short with three points, gubernaculum present.
3. External lateral and external dorsal rays are shorter than the medio-lateral and postero-lateral rays.
4. The various species are found in mammals.

Cameron constituted the genus *Molineus* to hold his new species *M. felineus* obtained from the intestine of *Felis yaguarandi* in S. America and a worm described by Molin which had been previously called *Strongylus torulosus*. Since that time the number of species in this genus has been augmented by Sprehn 1928 who introduced *M. americanus*, a species recovered from a mink, *Lutreola* (or *Mustela*) *vison*, imported into Germany ; by Zunker 1928 with *M. europaeus* from *Putorius putorius* in Germany and by De Muro in 1933 with *M. vogelianus* from *Perodicticus potto*. Of these five species I am of the opinion that *M. americanus* is synonymous with *M. patens*. Judging from the photograph and description given by Sprehn the spicules, which seem to be an important diagnostic feature, appear to conform in every way with those of *M. patens* except that their length is given as 0·19 mm. as opposed to 0·15 mm. The disposition of the rays of the bursa are very similar, the only difference being that the dorsal ray and the medio- and postero-lateral rays reach the edge of the bursa in *M. patens* but not in *M. americanus* according to the diagram. The only other differences are in matters of length, Sprehn's worms being a little longer than those now described, his measurements being ♂ 8 mm. and ♀ 10–12 mm. ; the eggs too would seem to be a little longer than those of *M. patens* but this may be due to the fact that eggs of this worm were only obtainable from the uterus. These slight differences I consider are not sufficient to constitute two separate species, I therefore am forced to the conclusion that *M. americanus* is a synonym of *M. patens*. As hosts, *Lutreola vison*, *Mustela erminea* and *Mustela nivalis* are closely related zoologically ; this is another fact in favour of the above opinion.

M. europaeus also closely resembles *M. patens*, but in considering their relationship one is hampered by a rather inadequate description

of the spicule. Although Zunker considers the form and size of the spicules to be important in diagnosis, he limits himself to giving the length as 0·145 mm. and states that the proximal end is blunt and the distal end divided into three sharp points. In his figure the three sharp points are shown as being of approximate equal length, but from the more detailed anatomy given here it would be interesting to examine the type material of *M. europaeus* further. The bursa of this species would seem to be identical with that of *M. patens*.

M. torulosus, originally described by Molin 1861, differs not only from *M. patens* but from all the other species of *Molineus* in the shape of the spicules, one point of which is distinctly barbed. The bursa also is different from the above-mentioned species in the position of the antero-lateral ray which diverges from the medio-lateral at its base.

M. vogelianus is also easily differentiated from the other members of this genus by means of the spicules which contain a number of short sharp spines at the posterior portion of one of the three points. The bursa appears to differ in that all the rays diverge from one another at their origin.

M. felineus, the type species, is smaller than any of the above-mentioned species. The bursa is similar to *M. patens* but the spicules terminate in three comparatively simple points of approximate equal length.

Since this paper was prepared for press, Cameron (1936) has published an account of three new species of *Molineus* from South America, viz. *M. pardalis* from *Felis pardalis*, *M. major* and *M. barbaris* from *Tayra barbara*.

In both *M. major* and *M. barbaris* the dorsal ray differs markedly from known species. In *M. major* the trunk gives off a lateral ray on either side at the point where it divides into two branches each of which in turn is split at the tip. In *M. barbaris* the dorsal trunk is split deeply and a lateral ray is given off half way along each of the prongs. In *M. pardalis* the dorsal trunk resembles closely that seen in the known forms in that the dorsal trunk extends undivided to near the edge of the dorsal flap of the bursa where it splits into two short branches each of which gives off a lateral ray and almost immediately divides again into two short terminal prongs. *M. pardalis* is, however, less than half the size of *M. patens* even when fully mature.

SUMMARY.

1. Presence of *Molineus patens* in England is recorded for the first time.

2. A more complete description is given of the morphology of *M. patens* including details of the spicules of the male and of some interesting papillae in the female tail.

3. The species of the genus *Molineus* are reviewed and compared and the suggestion is made that *M. americanus* is a synonym of *M. patens*.

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Journal of Helminthology, Vol. XIV, *No.* 3, *September*, 1936, *pp.* 127–130.

Some Experiments and Observations on the Longevity of *Diphyllobothrium* Infections.

By R. T. Leiper, M.D., D.Sc., F.R.S., F.R.C.P.

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In an article on " The Longevity of *Diphyllobothrium latum* " published in 1935 in the " Recueil des Travaux dédié au 25-me Anniversaire Scientifique du Professeur Eugène Pavlosky 1909-1934 ", it is suggested that present day conceptions regarding the longevity of this parasite are erroneous and that multiple successive infections are frequently attributed to a single long-lived specimen. Ward gives a detailed review and analysis of the evidence hitherto published both in general works and special monographs and cites as specially important the history of the occurrence of this species on the North American continent. He points out that the age of the parasite is regularly based on the statement that the host had not been in an infected region for the period indicated. To this statement, Ward puts forward the objections that the distribution of the parasite and the natural occurrence of plerocercoid carrying fish are far more extensive than was formerly suspected and, further, that infected fish are distributed commercially as food to regions far outside their natural area of distribution. He also refers to certain records which seem to indicate that there is a " period of inactivity " during the adult life of the parasite and suggests that its alleged occurrence throws doubt upon the supposed longevity of the parasite. In support of this contention, he cites, as a typical instance, a case of human infection with *Diphyllobothrium latum* reported by me (Leiper, 1928) as a " cryptic infection " ; regarding which he erroneously states that I believed was " latent " for 5 years. The case reported by me came under observation in the following circumstances. In order to study experimentally the character of the pernicious anaemia which has been so commonly associated with *Diphyllobothrium* infections, I visited Neuchatel in 1922, with the assistance of a grant from the Medical Research Council, and obtained from the lake fish there a number of living plerocercoids. These were brought back to England in Ringer's

solution. Those which survived were enclosed in pieces of bread and were swallowed by two of my colleagues, by myself and by a cat. Blood films were taken each day at noon and the interesting rise in the eosinophilia which took place during the first 6 weeks and afterwards fell to normal in the succeeding 3 months was reported upon by Miss G. LeBas (1924).

As a result of later treatment by Carbon Tetrachloride, of the 3 persons who had submitted to experimental infection, the number of tapeworms passed corresponded exactly with the number of plerocercoids swallowed except in my own case, reported by Miss LeBas as " Case A," where 3 complete adult worms were removed although 4 plerocercoids had been swallowed. After this brief visit to Neuchatel in 1922, I remained in London until the end of 1927 when I visited Cairo on an official mission to advise the Egyptian Government on the question of Bilharzia control. I arrived in Egypt on 11th December, 1927. During my stay in Cairo I contracted an acute attack of dysentery and on the 8th February, 1928, as a result of a personal examination of my faeces for *Entamoeba histolytica*, I discovered vast numbers of eggs of *Diphyllobothrium latum*. For purposes of study I retained the infection for 10 months. Not only had there been a complete absence of passage of tapeworm segments from the initial infection on 27th September, 1922, and during my illness in February, 1928, but this complete absence continued, although eggs were constantly present in the stool, until the adult tapeworm was finally removed by treatment in December, 1928. The conclusion at which I arrived was that, although the parasites had developed normally, in my case the mature segments were continually digested, whereas in the cases of my two colleagues, long portions of strobila were passed intermittently. Lest it be suggested that strobila were passed but overlooked, I may add that I have always followed the advice given by Manson to his students to observe daily the character of one's own stools as an index of intestinal health.

Ward states that he finds it difficult to agree with my view that there was a four year period of " total inactivity " in this instance and states that one can much more easily assume that a second infection had been acquired. I may comment here that I did not claim " total inactivity " but merely a continued absence of the *passage* of segments. The sustained passage of innumerable eggs which was observed between

my illness which led to their microscopical detection and the subsequent treatment by which the adults were removed showed that the tapeworms were maintaining their normal growth and sexual activity. Ward further explains the absence of eosinophilia as possibly due to the intercurrent attack of dysentery. It seems, however, more plausible to assume that the absence of eosinophilia had continued, as in the cases of my other colleagues, after the initial rise and fall which Miss LeBas had recorded.

Although my colleagues and I experienced at times a certain amount of discomfort in the earlier months of our infections the symptoms were nearly always of a vague character and perhaps the most constant was an heightened sense of hunger before the usual meals. The removal of the tapeworm after the second treatment was, in my case, followed in the succeeding months by a general improvement in health and adiposity.

In Miss LeBas' clinical report of my case there is a significant paragraph to the effect that the symptoms of dragging pain in the region of the ileo-caecal valve and of a certain amount of epigastric disturbance, continued after the treatment which resulted in the removal of worms, whereas these disappeared in the two other cases. Miss LeBas' comment on this persistence of symptoms is " that it is probable that they should not be definitely attributed to the presence of the worm," but in the light of my subsequent experience these symptoms were more probably due to the fact that all the worms were not removed at that time.

That I acquired an infection from eating imported fish in London seems an exceedingly remote supposition. The only occasion on which infection could have been acquired during my visit to Egypt was at a picnic lunch at Christmas time ; one of the ingredients of which was a smoked salmon sandwich. A new infection so long after an earlier one should, however, have given rise to a new eosinophilia. Moreover, from the date of the discovery of the eggs in Egypt until the removal of the tapeworm 10 months later, there was again an entire absence of the passage of segments.

If, in spite of these further details, Professor Ward is still unable to accept the above record as evidence that *Diphyllobothrium latum* can live in man for a period of 5 years, he cannot scarcely refuse to accept the following collateral evidence that *Diphyllobothrium mansoni*

can live in its natural host, the dog, for a period of 8 years. In 1925, I obtained some plerocercoids from a snake which had died in the Zoological Gardens of London. These were fed to a puppy which had been kept for some months previously in one of the kennels at the Institute of Agricultural Parasitology, St. Albans, and which had been proved, by microscopical examination of the faeces, to be free from tapeworm infection. Some weeks later, typical eggs of *D. mansoni* began to appear in the faeces and were passed in increasing numbers. These were subsequently used for the purpose of repeating the life-cycle of *D. mansoni*. English specimens of *Cyclops viridis* were infected with the onchospheres hatched from these eggs. In white mice which were fed with these infected cyclops plerocercoids were subsequently found. The whole life-cycle was completed by feeding these infected mice to dogs. The infected dog was kept in confinement in the premises of the Institute of Agricultural Parasitology on a supervised diet for nearly 10 years. For *eight* years it retained the original infection. Considerable lengths of strobila were passed during this period, after which time the infection was lost.

I agree with Professor Ward that the recent discoveries of *Diphyllobothrium latum* in many persons born in North America and of the prevalence of plerocercoids in the edible fishes of the great lakes, may throw some doubt on the longevity of those tapeworm infections which have been reported in Finnish, Polish and Russian immigrants into the United States. Nevertheless, the experimental cases cited above seem sufficient to controvert the conclusions reached by Ward from his consideration of the literature bearing upon the longevity of *Diphyllobothrium latum*.

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Journal of Helminthology, Vol. XIV, *No.* 3, *September,* 1936, *pp.* 131–134.

Hymenolepis chrysolampidis n. sp., a parasite of *Chrysolampis mosquitus* of Brazil.

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The material forming the basis of the following account was collected from a ruby-crested humming bird, *Chrysolampis mosquitus*, a native of Brazil. This bird died in the gardens of the Zoological Society of London and the parasites were forwarded for identification to Dr. R. T. Leiper, F.R.S., of the London School of Hygiene and Tropical Medicine.

The bottle contained one complete worm and a number of fragments including an extra scolex. On examination the material was found to belong to the genus Hymenolepis, but it could not be assigned to any of the many known species. It is proposed, therefore, to make a new species and to allocate to it the name *Hymenolepis chrysolampidis* n. sp., which name will indicate the host of the worm.

The complete worm, which was already fixed in formalin on arrival, measured 19 mm. long by 0·7 mm. broad at its widest part. It was sturdy and thick and its width rapidly increased behind the scolex to its full measurements.

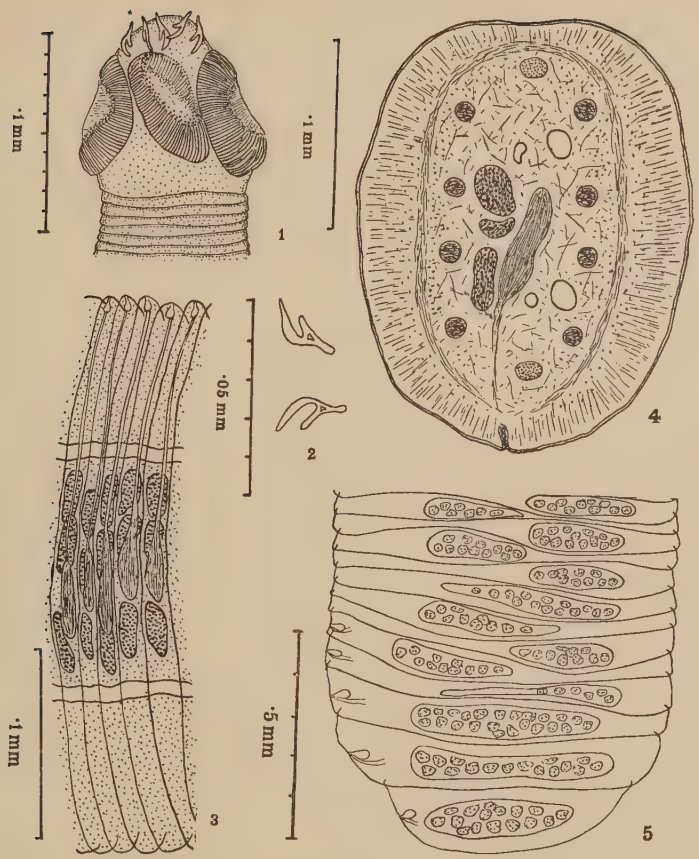
The scolex (Fig. 1) is strongly developed, measuring about 100μ broad by 85μ long and bearing 4 muscular suckers. These are so large as to occupy most of the surface of the scolex. There is a very small rostellum which can be retracted into a shallow sac. On one of the available scolices some of the hooks had been lost, but the other one was complete. It showed a retracted rostellum which carried a single ring of strong sharply pointed hooks, 10 in number. They are curved and measure 18–20μ in length (Fig. 2). The suckers are oval, large and muscular. They measure 70μ long by 30μ broad.

The strobila is segmented immediately behind the head, there being no apparent neck. It consists of a large number of very narrow segments. The water vascular system (Fig. 4) is very conspicuous, particularly in

the early segments before the genital rudiments can be picked out. It appears as two prominent canals which take a wavy course, marking out the segment roughly into thirds. These are the dorsal canals. There are also a pair of ventral canals which are much less prominent but which can be seen in transverse sections. The systems are connected in each segment by transverse anastomoses.

Underneath the transverse muscular layers of the body wall there are 8 longitudinal muscle bands all of about the same size, and consisting of longitudinal spindle-shaped fibres. Four of these bands are dorsal and the others are ventral. They are interrupted at intervals along their length. The nerve cords are lateral to the muscle bands and pass at the level of the excretory canals (Fig. 4).

In the first segments immediately behind the scolex no organisation has yet occurred, but once the genital analogon have become apparent, differentiation takes place rapidly and the three testes can be seen to lie in a straight line across the middle of the segment, being strictly delimited by the dorsal excretory vessels. The testes are flattened oval bodies. As the segments are so narrow considerable pressure is brought to bear on the organs, and it happens therefore that the testes of one segment tend to alternate with those of its immediate neighbours. The genital pores are unilateral and open about the middle of the edge of the segment. There is a very small cirrus sac leading into a prominent muscular vesicular seminalis which extends at least to the middle of the segment and in some almost to the antiporal excretory canal. The ovary is a small bilobed organ which develops between the middle and antiporal testes and posterior to them. When the ovary appears in the segment the male glands rapidly disappear. The yolk gland is very inconspicuous. The uterus develops as a simple sac and, as in the case of the testes, it is necessary for the uteri of neighbouring segments to alternate. The alternation of organs is indeed more marked here than anywhere else in the strobila, for in the gravid part of the worm it is seen that the uterus of one segment lies to the right and that of the neighbouring segments to the left of the worm. In the oldest segments the shape deepens a little, thereby relieving the pressure so that the uterus then becomes central, occupying the whole of the space available. The onchospheres are small, measuring not more than 20μ diameter. They are not particularly abundant.



Hymenolepis chrysolampidis. n. sp.

Fig. 1. Scolex.

Fig. 2. Hooks removed from the scolex.

Fig. 3. Proglottides showing male genitalis and dorsal excretory canals.

Fig. 4. Transverse section showing testes, vesicular seminalis, excretory canals, nerve cords and the 8 longitudinal muscle bands.

Fig. 5. Gravid segments showing uteri with onchospheres.

Affinities of *H. chrysolampidis*.

This species resembles most closely *H. brasiliense* Fuhrmann 1906 which occurs in *Caprimulgus carolinensis*, a nightjar, and *Nyctoprogne leucopygia* which seems to be a synonym of *Poliospiza leucopygia*, the grey singing finch inhabiting the Nile regions. The distribution of *H. brasiliense* is given as the West Indies to Brazil.

There are two main differences between these two worms. Fuhrmann gives the length of the rostellar hooks of *H. brasiliense* as being 0·03 mm., while in the present species the length never exceeds 0·02 mm. He describes the cirrus sac as reaching to the antiporal excretory canal right across the segment. In this worm the cirrus sac is small, but is connected with a large muscular vesicular seminalis which extends to the middle of the segment or further as has been described above. The onchospheres are given as measuring 0·025 mm. diameter which is just a little larger than those of *H. chrysolampidis*, but this difference might easily be accounted for by different methods of fixation. In other respects the anatomy of the two worms seems to approximate very closely and the two would seem to be nearly related.

It hasr elationships also with *H. pachycephala* (von Linstow 1872) *H. furcifera* (Krabbe 1869), *H. aequabilis* (Rudolphi 1810), *H. exigua* Yoshida 1910, *H. rectacantha* Fuhrmann 1906 and *H. musculosa* Clerc 1903, all of which have the testes in a linear row and a rostellum with 10 hooks, but they can all be distinguished by the shape of the hooks.

The hooks of *H. chrysolampidis* resemble in appearance those of *H. nyrocae* Yamaguti 1935, which however are only 9μ long and of which there are 16. *H. capillaroides* also bears a superficial resemblance to *H. chrysolampidis* but can be distinguished by the disposition of the testes and the extent of the cirrus sac.

Types in the collection of the Department of Helminthology of the London School of Hygiene and Tropical Medicine.

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Journal of Helminthology, Vol. XIV, *No.* 3, *September*, 1936, *pp.* 135–140.

Ridding Pasture of *Taenia saginata* ova by Grazing Cattle or Sheep.

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H. Boyd Penfold, M.H., B.S.
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and

Mary Phillips, B.Sc.
(*From the Baker Institute of Medical Research, Alfred Hospital, Melbourne.*)

Introduction.

Beef measles is prevalent in many parts of the world. The two most important factors which allow the dissemination of the disease are, firstly, the insanitary methods of the disposal of human excreta, and secondly, the habit of eating beef raw or almost raw. To eradicate beef measles and *Taenia saginata* from a country where the inhabitants are eaters of raw beef, would be a costly and difficult undertaking. The fact that *Taenia saginata* infestation of man is a comparatively trivial disease and, therefore, does not induce many infested persons to seek treatment, is another difficulty in preventing its dissemination. Of 90 cases that came to our notice, 65 did so in reply to an offer of £5 reward for a complete tapeworm (1), and, although the average duration of infestation of these cases was 13 years, many had never previously sought treatment. We consider there are two main methods of preventing bovine cysticercosis. The first is to immunize the cattle against the disease, and the second is to prevent cattle from having access to *Taenia saginata* eggs. With regard to the second method, if means are undertaken to prevent *Taenia saginata* ova from gaining access to a pasture previously contaminated with them, the problem still remains of getting rid of the ova which are already present. This paper considers the latter problem, and is specially applicable to farms irrigated with human sewage. It has been suggested that pastures may be ridded of *Taenia saginata* eggs by grazing sheep. We agree with this view after

having performed the following experiments. The questions investigated in the first experiment were :—

(1) Will sheep develop the cystic stage of *Taenia saginata*?

(2) During the three days immediately after feeding, will the faeces of sheep fed with *Taenia saginata* eggs contain onchospheres and/or eggs capable of producing measles in cattle?

(3) During the three days immediately after feeding, will the faeces of calves fed with *Taenia saginata* eggs, contain onchospheres and/or eggs capable of producing measles in cattle?

Materials.

Stock : 2 male 4-year old sheep and 4 clean male calves 6–10 months old.

Eggs : A batch of fresh *Taenia saginata* eggs divided into three doses each of 100,000.

Branding : One sheep was ear-marked with a V on the lower aspect of the left ear. The other was marked VV in the same position. The four calves were branded 4C, 4S, 4S1, and 4F, respectively, on the near side rump.

Procedure and Results.

All the animals were fed on dry feed for the 24 hours immediately preceding the commencement of the experiment. After attempts had been made to infest them, they were kept separately from one another for a further period of 24 hours, after which they were depastured for approximately 7½ weeks on land that had never at any time been irrigated with sewage. The 7½ weeks after drenching were allowed so that measles would have ample time to develop. After slaughter every animal was carefully examined. The whole of each sheep's carcase, including the organs, was cut up into slices not more than ¼″ in thickness. The heart, masticatory muscles, tongue and diaphragm of each calf were examined in detail (slices ⅛″–¼″ in thickness). From past experience we consider that, if an ox is not infested in these sites of election, the chance of its being infested in the dressed carcase is extremely small—so small as not to be of any importance in an experiment where large numbers of viable ova are administered.

(A) The calf branded 4C was drenched with 100,000 *Taenia saginata* eggs. The whole of its faeces for the next three days was collected and fed, while fresh, to the calf branded 4F. At the post mortem examinations the calf 4C was found to be heavily infested (305 cysts in the sites of election), while the calf 4F contained no cysticerci. The infestation of the calf branded 4C proved that a representative sample of the eggs of the batch was infective to the ox. The negative result obtained in the calf 4F suggests that viable eggs or onchospheres do not escape in the faeces of calves to which ova are fed. We have confidence in this conclusion, although only one animal was involved, because 88 oxen bought on the open market were all shown to be susceptible to *Cysticercus bovis*.

(B) The sheep marked V was drenched with 100,000 fresh eggs. All its faeces was collected twice daily for the succeeding three days. It was administered, as soon as collected, with water in the form of a drench to the calf branded 4S. Both animals were then depastured on clean land. When slaughtered, neither of the animals showed any signs of *cysticerci*. These results showed that the sheep was not susceptible to *Cysticercus bovis*, nevertheless it did not excrete in its faeces viable *Taenia saginata* eggs or onchospheres.

(C) The sheep marked VV was drenched with 100,000 eggs. Its faeces was collected for the following three days and exposed to mild meteorological conditions for ten days. There was practically no sun and no rain. It was then fed with water in the form of a drench to the calf branded 4S1. After a period of grazing on clean land for 7½ weeks they were slaughtered and examined. No *cysticerci* were found in either animal at the carefully conducted post mortem examinations. These results would be expected from those described above (B) which they serve partly to confirm.

Conclusions.

(1) In all probability sheep will not acquire *Cysticercus bovis*.

(2) By grazing sheep or cattle under conditions to be determined, pasture contaminated with *Taenia saginata* ova can be freed of its contamination.

Pasture-Cleaning Experiment.

An experiment was carried out to determine the conditions necessary to clean land contaminated with *Taenia saginata* ova by depasturing upon it cattle, or cattle and sheep.

Materials.

Ten million *Taenia saginata* eggs, which had been stored at 2–5° C. for 9 weeks.

16 clean 8–12 months old calves.

15 sheep.

An area of 2 roods 2–9/10 perches, which, before the commencement of this experiment had been irrigated for years with raw sewage.

Procedure and Results.

24/7/34. The experimental pasture was irrigated with raw sewage to which 10 million *Taenia saginata* eggs had been added. The grass at this stage was approximately 4″ long. The area was not irrigated again until the whole of this experiment was completed.

30/7/34. Five clean calves (Group I) were admitted to the experimental pasture.

25/8/34. The grass having been eaten as closely as possible (length ½″–1″), the calves were removed to clean land to allow the cysticerci to develop. The experimental area was divided into two equal portions by a fence running in the direction of the flow of the sewage with which it had been irrigated.

5 weeks 2 days later the five calves were slaughtered, and the sites of election were cut into slices of ⅛″–¼″ in thickness and carefully examined. The total number of cysticerci found was 349.

30/8/34. Fifteen sheep were put on the northern sub-division of the experimental area to eat the grass as closely as possible. This was accomplished by 3/9/34, when the sheep were removed and the grass allowed to grow. The grass was already so short when the sheep were depastured that they could not eat it much more closely.

19/9/34. By this date the grass on both areas had grown considerably. It was approximately 6″ long in the southern subdivision; that on the northern, where the sheep had been, was approximately 5″ long. Two

clean calves were put on the northern subdivision and three on the southern subdivision. The five animals are subsequently spoken of as Group 2.

6/10/34. The calves from both subdivisions were transferred to clean land because the grass of the experimental area had been eaten as closely as possible. Five and a half weeks later they were slaughtered and the sites of election examined. The two calves together that had been depastured on the northern subdivision contained 25 cysticerci in the sites of election. The three calves from the southern subdivision had 22 cysticerci.

2/11/34. By this time the grass on both subdivisions was approximately 7″–8″ high. Three clean calves (Group 3) were placed on each of the subdivisions.

21/12/34. The calves were removed to clean land, as the pasture of the experimental area had been eaten as closely as possible. Six weeks later they were killed and examined by cutting the sites of election into slices $\frac{1}{8}$″–$\frac{1}{4}$″ in thickness. The calves that had been depastured on the northern subdivision showed no *cysticerci*. The three calves that had been on the southern subdivision showed a total of only two *cysticerci*.

As the depasturing of the sheep made no appreciable difference in this experiment, for the purpose of a tabulated summary they will be omitted.

Date of last contamination of experimental area.	Cattle Group.	Period of depasturing cattle on experimental area.	Total number of *cysticerci* in sites of election of the 3 groups of cattle.
24/7/34	1	30/7/34 to 25/8/34	349 (100%)
,,	2	19/9/34 to 6/10/34	47 (13·5%)
,,	3	2/11/34 to 21/12/34	2 (0.6%)

Remarks.

The degree of contamination of the experimental pasture can be represented for practical purposes by the number of cysts developed in cattle grazing on it. The results of this experiment show that the degree of accessible contamination at the various times of testing was reduced from 349 to 2. This represents a reduction of effective accessible eggs to 0·6% of the original number. This appears very satisfactory from the practical point of view. Three factors could be involved in producing this experimental result :—

(1) The cattle in Groups 1 and 2 had eaten possibly the majority of eggs which would ever be accessible to cattle. This factor probably did operate, as shown by the results of the first experiment recorded in this paper, but it may not have been the only or even the chief factor.

(2) The eggs were nine weeks old before they were put on the experimental pasture. Before the cattle of Group 3 were placed on the land, any of these eggs that remained must have been $25\frac{1}{2}$ weeks old $(9+14\frac{1}{2})$. Some fresh eggs may have been present in the sewage used for the last irrigation. If so, they would only be $14\frac{1}{2}$ weeks old. The effect of ageing of the eggs in all probability was an additional factor involved in reducing the degree of effective contamination. We have shown that eggs kept in saline at 2–5° C. are not viable after $16\frac{1}{2}$ weeks.

(3) The effect of the meteorological conditions prevailing during the period of the experiment may be partly responsible for the results. Here again, we cannot be dogmatic, but suggest that this was not a significant contributing factor.

We know that the first factor mentioned did operate to some extent. We know from the first experiment that if cattle ingest eggs, none of the eggs is any longer a menace to other cattle. In this cleaning experiment the cattle in each group ate all the eggs accessible to them during their respective periods on the experimental area. The experiment, therefore, proves that some few eggs which are not accessible to one group of cattle, even when the grass is eaten as short as possible by them, may become accessible to cattle subsequently depastured on the same land after the grass has grown. Exactly how this happens is problematical, but the most likely explanation seems to be that eggs which have been deposited low down on the grass are raised during its subsequent growth. It is possible that a small proportion of eggs actually on bare earth may be directly lifted to an accessible position by new shoots of grass or indirectly by the hoofs of grazing cattle.

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Journal of Helminthology, Vol. XIV, *No.* 3, *September,* 1936, *pp.* 141–162.

On some representatives of the Cestode Genus *Avitellina* from India.

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The genus *Avitellina* was proposed by Gough (1911) for the species *A. centripunctata* (Rivolta, 1874). Until the work of Woodland (1927) this was the only known species of the genus. Woodland (1927) was the first who examined more critically the material of this genus obtained from some different localities and described four new species of the genus : *A. sudanea, A. lahorea, A. chalmersi* and *A. goughi.* In the same paper he gave a thorough redescription of the type-species *A. centripunctata* from the material obtained from Bologna. Southwell (1929) pointed out that *Hexastichorchis* Blei, 1921 and *Anootypus* Woodland, 1928 are synonymous with *Avitellina,* consequently three more species were added to the genus, *viz., A. pintneri* (Blei, 1921), *A. edifontaina* (Woodland, 1928) and *A. ricardi* (Woodland, 1928). The same year Nagaty (1929) added two more species to this genus these being *A. southwelli* and *A. ægyptiaca.* Fuhrmann (1931) added the species *A. monardi.* Quite recently Woodland (1935) described *A. sandgroundi* from *Hippotragus equinus.* Fuhrman (1931) had adopted Southwell's opinion in regarding *Anootypus* Woodland as a synonym of *Avitellina,* but in his later publication he (Fuhrmann, 1933) disapproves of this procedure and considers *Anootypus* as a valid genus. In his opinion the absence of dorsal excretory vessel, only a single layer of longitudinal muscle and the position of cirrus sac dorsal to vulva are the points in favour of maintaining *Anootypus* as an independent genus. He therefore assigns his species *monardi* to *Anootypus* removing it from the genus *Avitellina.*

The writer has been interested in this genus since 1928 when he had made some collection of these worms at Muktesar and in the following year at Nagpur. He has also communicated a short paper on these worms to the Zoological Section of the Indian Science Congress held in Allahabad

in 1930. An abstract of this short communication has been published in the Proceedings of the Indian Science Congress of that year. The writer has made an additional collection of these worms in the recent years at Muktesar and in the discharge of his official duties he had an opportunity to examine some of these worms, particularly the species *A. chalmersi*, from the Bombay Presidency and the Punjab. The following is an attempt to submit a succinct report on the material at the disposal of the writer from four different localities in India. Woodland (1935) expressed much scepticism in regard to the existence of *Avitellina centripunctata* in India. The writer at the present moment does not possess any material which gives a clue to the existence of either *A. centripunctata* or *A. goughi* in India. On the authorities of Southwell (1930) and Meggitt (1927), however, these species do occur in India and the writer has taken this for granted without his having a personal opportunity to examine either of these two species.

Avitellina woodlandi n.sp. (Figs. 1-4)

Amongst a large number of tapeworms of goats collected in Muktesar was differentiated a worm belonging to the genus *Avitellina* which on examination proved new to science. It is proposed to give here a description of this new tapeworm.

The entire worm measured 60 centimetres in length. The minimum width of the worm, 0·57 mm., is in the neck region, some distance behind the scolex. The maximum width of 1·33 mm. is attained in the region where incipient segmentation is first noticed. The scolex is more or less a globular structure measuring 0·9 mm. × 0·7 mm. It is sharply marked out from the rest of the strobila by a constriction. The suckers on the scolex have a diameter of about 0·47 mm. The scolex is followed by a long neck portion measuring about 40 mm. in length and in this region there is no indication of segmentation. In the region immediately following the scolex, however, the margin of the strobila is somewhat crenulated to a distance of 1·62 mm. approximately. Posterior to the neck region incipient segmentation is visible, indicated by the rudimentary genital ducts. The external segmentation of the strobila gets more and more pronounced antero-posteriorly until at last it becomes very prominent in the gravid region of the worm.

The excretory system consists, as usual, of two canals on each side,

one dorsal and another ventral, the latter being situated external to the former. In the neck region both the excretory vessels have more or less the same diameter although the ventral excretory canals have a somewhat wider lumen. Later these ducts have a straight course throughout the entire strobila, but the dorsal canals are disposed in a zigzag manner in the neck region. As the ventral canals pass posteriorly they grow wider and wider until at last in the gravid region they attain their maximum width. Their minimum and maximum widths being 0·017 and 0·04 mm. respectively. On the contrary the dorsal excretory canals diminish in width as they pass posteriorly until at a distance of about 80 mm. from the scolex they disappear entirely.

The lateral longitudinal nerves pass approximately midway between the margins of the strobila and the ventral excretory canals.

The genital pores are irregularly alternate. The male genitalia consist of four longitudinal columns of testes arranged one on each side of the ventral excretory canals. The testes are spherical and measure 0·06-0·08 mm. when fully mature. The outer column of testes have a somewhat varying thickness in the different parts of the same piece of strobila. Their thickness varies even on different sides of the same portion of the strobila. At places the outer column is one-testis deep while in others it is two-testes deep. Rarely it is even three-testes deep. The testes do not extend laterally beyond the nerves. The internal column of testes is three- to five-testes deep and extends from the internal wall of the ventral excretory canal to the region of the ovary. The vas deferens, in the anterior region of the worm, is a straight duct, but posteriorly it becomes more and more coiled. The cirrus sacs are comparatively very large and differ in this respect from all the species of the genus recorded up to the present moment. Usually in this genus the cirrus sac is either smaller in length than the vulva or at the most is equal to it, but in the present species it is distinctly larger than the vulva. In a fully extended condition it is twice as large as the vulva, but in a somewhat contracted condition it is at least one and a quarter times the length of the vulva. They appear as transversely cylindrical sacs measuring 0·187–0·3 × 0·043–0·082 mm. The muscular cirrus lies almost straight in the cirrus sac and is occasionally seen protruding out of the lateral genital pore. It is situated in all cases anteriorly to the vulva and may be disposed dorsally or ventrally to the latter quite irrespective of the right or the

left side. In the vast majority of cases they lie ventrally to the vagina on both the sides. Woodland's statement that in this genus the cirrus sac lies, in a vast majority of cases, dorsal to the vulva on the right side and ventral to it on the left cannot be confirmed in this species.

The female genitalia consist of the ovaries which are disposed in two rows immediately internal to the inner columns of testes. The ovary is situated on the poral side in each segment ventrally and measures 0.065–0·07 mm. in diameter in the male-mature proglottides. An oviduct emerges out dorsally from the ovary which bifurcates into two ducts, the internal being the uterus and the external one enlarging into the receptaculum seminis after a short course. The receptaculum seminis is an oval sac measuring 0.092–0·15 × 0·061–0·075 mm. The largest receptaculum seminis is found in the region in which the paruterine organs have started to become gravid. The vagina, as usual, is a thin duct. The vulva measures 0·132–0·187 × 0·033–0·058 mm. and is situated posteriorly to the cirrus sac. Occasionally a small portion of the vulva overlaps the cirrus sac. The vulva may lie dorsally or ventrally to the cirrus sac irrespective of the right or the left side. It is covered, as usual, with glands. The genital ducts pass dorsal to the excretory canal and the nerve.

The paruterine organs are at first sac-like and are disposed in a single central line without alternating with one another as in some species of *Avitellina*. When these organs are fully mature they appear more or less intermediate between the forms that have been described by Woodland for *A. sudanea* and *A. lahorea*, converging more towards the former. The bladder is directed anteriorly. Even in the mature condition all the organs lie centrally in one line. The gravid paruterine organs tend to become sac-like with the bladder directed anteriorly. On either side of the central line of the mature paruterine organs are seen prominent rows of the receptaculum seminales : both the testes and the ovaries having disappeared in this region. The mature paruterine organs are confined to their own segments, but the gravid ones occupy antero-posteriorly a little more space than the breadth of the segment. The inter-proglottidal sheets of connective tissue are not so prominent in this species as in the case of *A. sudanea*. The mature paruterine organs measure 0·203 × 0·15 mm. As the paruterine organs get more and more gravid the bladder becomes

larger and larger until in the posterior part of the worm the paruterine organs are represented by the rounded bladders alone which have developed very thick walls and contain five to six egg capsules. The inter-proglottidal sheets of connective tissue are more prominent in this region. As a rule all the gravid paruterine organs lie centrally in one single line, however, a small tendency to alternate is noticed. The gravid paruterine organs measure $0{\cdot}32 \times 0{\cdot}3$ mm. and those in the posteriormost segments are 0·27–0·31 mm. in diameter. The ova in the egg capsules measure 0·054–0·057 mm. in diameter. Neither the egg capsules nor the ova are liberated into the excretory canals as in the case of *A. centripunctata* described by Woodland.

A comparison of the species described here with the species of *Avitellina* recorded up to the present moment indicates that it has closer affinities with the species *A. sudanea* Woodland, 1927. It can, however, be easily differentiated from this latter. In the first instance *A. sudanea* has the cirrus sac either smaller than or equal to the vulva while in the species described here the cirrus sac is distinctly larger than the vulva. In this respect it differs from all the known species of *Avitellina*. The inter-proglottidal sheets of connective tissue are very prominent in *A. sudanea* while in the species described they are almost insignificant excepting in the gravid segments. The description of the outer column of testes might reveal that the writer's specimen differs from *A. sudanea* in this respect, but the writer is not inclined to attach much significance to this character since he found that even in *A. sudanea* the outer column of testes is occasionally subject to the same kind of variation. In the genus *Avitellina* the paruterine organs have a tendency to be either pear-shaped, kidney-shaped or snail-shaped. In the writer's specimen the paruterine organ is somewhat intermediate between the snail- and kidney-shaped condition. In *A. sudanea* the paruterine organs never overlap each other but in the specimen described the gravid ones do overlap each other although the posteriormost organs lie again separately. In *A. sudanea* the testes persist even in the gravid segments, but in the writer's specimen they disappear even by the maturity of the paruterine organs. In the writer's specimen the receptaculum seminales are more prominent than in *A. sudanea*. Since the specimen described here differs in so many essential points from *A. sudanea* to which it is the most allied it is necessary to regard it as a new species for which the name *Avitellina*

woodlandi is proposed in honour of Professor W. N. F. Woodland who has contributed so much to the knowledge of the genus *Avitellina*.

Specific diagnosis.—Avitellina : Length 600 mm. Width 0·57–1·33 mm. Dorsal as well as ventral excretory canal present. Genital pores irregularly alternate. Testes in four columns : the outer being one- or two-testes deep and the inner three- to five-testes deep. Testes disappear by the maturity of the paruterine organs. Cirrus sac anterior and, as a rule, ventral to vulva, one and quarter to two times longer than the latter. Mature paruterine organs lie in a single straight line, their shape being intermediate between the snail- and kidney-shaped condition. Gravid paruterine organs partially overlapping antero-posteriorly and slightly alternating. Posteriormost paruterine organs rounded and separate. Receptaculum seminales very prominent even in gravid segments. Vulva smaller than cirrus sac, usually dorsal to the latter. Genital ducts pass dorsal to excretory canals and nerve. Inter-proglottidal sheets of connective tissue not prominent. Eggs measure 0·054–0·057 mm. in diameter.

Host.—*Capra hircus.*

Location.—Intestine.

Locality.—Muktesar (U.P.) and Nagpur (C.P.), India.

Type-slide to be deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar-kumaun.

Explanation of Figures

Fig. 1. *Avitellina woodlandi* n.sp., scolex. ×40.

Fig. 2. *Avitellina woodlandi* n.sp., dorsal view of a male mature strobila. ×40.

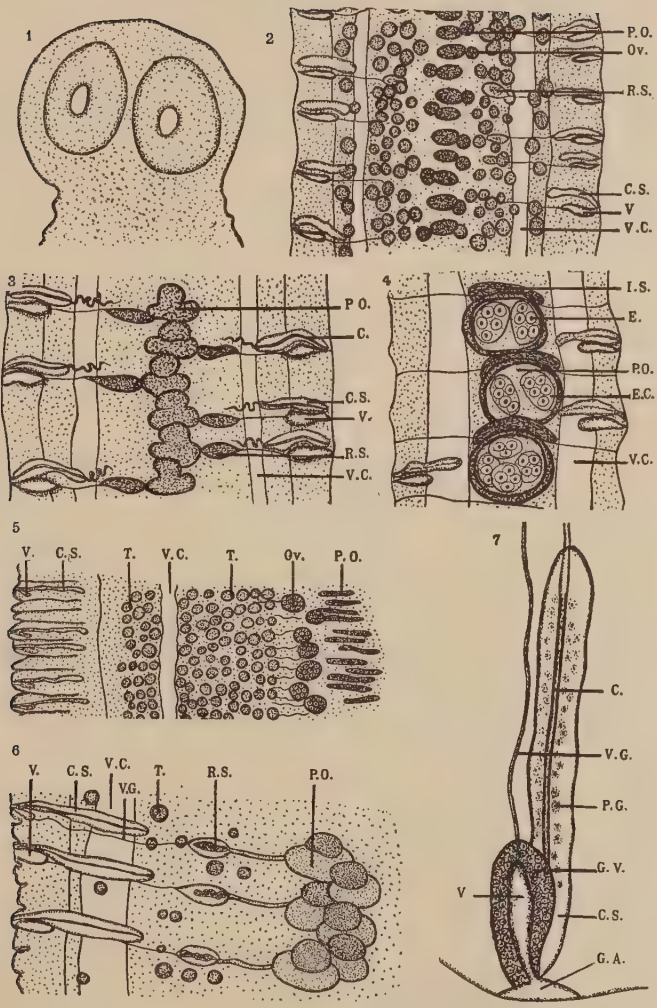
Fig. 3. *Avitellina woodlandi* n.sp., dorsal view of strobila in which paruterine organs have attained maturity. ×40.

Fig. 4. *Avitellina woodlandi* n.sp., segments of the gravid posterior region. ×40.

Fig. 5. *Avitellina tatia* n.sp., dorsal view of half strobila in which paruterine organs are beginning to develop, but male genitalia are fully developed. ×40.

Fig. 6. *Avitellina tatia* n.sp., dorsal view of half strobila in which paruterine organs have attained maturity and testes have to a large extent disappeared. ×40.

Fig. 7. *Avitellina tatia* n.sp., cirrus sac and vulva magnified. ×167·5.



Figs, 1-4 *Avitellina woodlandi* n.sp. Figs. 5-7 *Avitellina tatia* n.sp.
[For explanation of abbreviations see pp. 161–162]

Avitellina tatia n.sp. (Figs. 5-8)

Amongst the tapeworms of goats collected at Muktesar a few pieces of strobila could be differentiated from others which on examination proved to be a hitherto unknown species of *Avitellina*. It is proposed to give a brief description of the species from the material at the disposal of the writer.

The scolex and the neck region is unrepresented in the collection, but these are not so significant from the standpoint of the specific determination in this genus.

The worm as a whole is comparatively broader than the other species of the genus and the segments are short antro-posteriorly. Of the pieces of strobila the one with the mature paruterine organ is the broadest and measures 2·47 mm. in width and that with the gravid paruterine organs is 2·16 mm. wide. The youngest portion of the strobila available for study is the region in which the testes as well as the ovaries are quite well developed, but the paruterine organs are represented only by transverse tubules. The external segmentation is quite distinct in this region. The dorsal excretory canals were not represented in this region, presumably they are present in the still more anterior portion of the worm. The ventral excretory canals are 0·055 mm. wide in this region and in the region of the gravid proglottides they measure 0·2 mm. in width.

The longitudinal nerves pass laterally almost midway between the lateral margins of the strobila and the ventral excretory canals.

The male genitalia consist, as is typical of the genus, of four longitudinal columns of testes, the ventral excretory canals forming a barrier between an outer and an inner column on each side. The testes are spherical and measure 0.047–0·055 mm. in diameter when mature. The outer column of testes is three- to four-testes deep. The inner column of testes is five- to eight-testes deep. The former runs between the nerve and the outer border of the ventral excretory canal, while the latter extends from the inner border of the ventral excretory canal to almost the row of ovaries on its side. The vas deferens is in the anterior part of the worm, a straight duct, but posteriorly it becomes zigzag. The cirrus sac is, as in the preceding species, larger than the vulva, but in this species it is still larger than in *A. woodlandi*. In the fully extended condition it is at least three times larger than the vulva and in the region

of the mature paruterine organs it is a little more than even four times the length of the vulva. The cirrus sac is transversely cylindrical and measures 0·303–0·395 × 0·042–0·05. The muscular cirrus lies almost straight inside the cirrus sac and is occasionally seen everted out of the latter. The cirrus sac is in all cases situated anteriorly to the vulva and and observations made in more than a hundred cases indicate that it lies dorsal to the latter irrespective of the right or the left side of the strobila. In this case also Woodland's observation, that in the vast majority of cases the cirrus sac of the right side lies dorsal to the vulva and that on the left side ventral to it, cannot be confirmed. In this respect the writer agrees with Southwell (1929) and Nagaty (1929).

The female genitalia consist of the ovaries which are disposed in two rows, one on each side of the central paruterine organs. Since the segments are very short the ovaries in each column are very closely situated. In each segment the ovary is situated ventrally towards the poral side and measures about 0·1 mm. in diameter. The vulva is more or less a thick pyriform tube measuring 0·93×0·27 mm. It is, as usual, covered externally with glands. In all the cases studied the vulva was found to lie ventrally and posteriorly to the cirrus sac. The cirrus sac partially overlaps the vulva in the dorso-ventral plane. The vagina is, as usual, a thin duct passing straight internally and enlarging into the receptaculum seminis. This latter is an oval sac measuring 0·104–0·143×0·049–0·06 mm. The receptaculum seminales are arranged in two lines, one on each side of the central paruterine organs, midway between the latter and the ventral excretory canals. The genital pores are irregularly alternate. Both male as well as the female genital ducts pass dorsal to the excretory canal and the nerve.

The paruterine organs arise as simple lines alternating irregularly. When mature they appear like the buttons of a shirt. They are arranged alternately in two rows, with the bladders directed anteriorly. They measure about 0·246×0·19 mm. and occupy more than the width of a single segment antero-posteriorly. The interproglottidal sheets of connective tissue are not so prominent as in *A. sudanea*. The gravid paruterine organs are pear-shaped and measure about 0·6×0·34 mm. These latter are alternating and are very closely packed centrally in the entire space between the ventral excretory canals. Remnants of the cirrus sac, vulva and receptaculum seminis are seen in the gravid strobila.

The eggs measure 0·045 mm. in diameter. They are not liberated into the ventral excretory canals.

The species described here differs from all the existing species of the genus in respect of having the cirrus sac larger than the vulva instead of its being either equal to or smaller than the latter. In this respect, which in the opinion of the writer is a very important one, it is allied to the species *A. woodlandi* described in an earlier part of this communication. It can, however, be differentiated very easily even from this species. In *A. woodlandi* the cirrus sac is at the most twice as large as the vulva, but in the species under discussion it is three or more times larger than the vulva. In the species under discussion the vulva is ventral and not, as a rule, dorsal to the cirrus sac as in *A. woodlandi*. The outer and inner column of testes in this species are three- to four- and five- to eight-testes deep, whereas in *A. woodlandi* these are one- to two- and three- to five-testes deep respectively. The mature paruterine organs in this species are like shirt buttons and alternate with each other in such a manner that they appear to be disposed in two longitudinal rows, whereas in *A. woodlandi* they are slightly of a different shape and are disposed in one central line. The gravid paruterine organs in this species are pear-shaped instead of round. The vesicula seminales are not so prominent in the region of the mature paruterine organs; moreover, the post-receptacular portion of the vagina is considerably larger in this species, whereas in *A. woodlandi* the corresponding portion of the vagina is insignificant. The segments are comparatively shorter and broader than in *A. woodlandi*. These points of difference being sufficiently significant it is considered to regard the species under discussion as a new one for which the name *Avitellina tatia* is proposed.

Specific diagnosis.—Avitellina : Segments short and broad. Width 2·16–2·47 mm. Genital pores irregularly alternate. Outer column of testes three- to four-testes deep, inner column of testes five- to eight-testes deep. Cirrus sac three to four times longer than vulva, antero-dorsal to the latter. Mature paruterine organs like buttons of a shirt, alternating, disposed in two rows and extending antero-posteriorly more than the width of a segment. Gravid paruterine organs pear-shaped. Post-receptacular portion of the vagina considerably long. Vulva ventral to cirrus sac, posterior to the latter. Genital ducts pass dorsal to excretory

canal and nerve. Interproglottidal sheets of connective tissue not prominent. Eggs measure about 0·045 mm. in diameter.

Host.—*Capra hircus.*

Location.—Intestine.

Locality.—Muktesar (U.P.), India.

Type slide to be deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar, India.

Avitellina chalmersi Woodland, 1927. (Figs. 9-14, 18)

The species was originally described by Woodland (1927) but his description was based on some fragments of the worm obtained from sheep in Khor Barboi, N. Africa. The material at the disposal of Woodland being scanty the description of the worm given by him is by no means complete. This species appears to enjoy quite a wide distribution in India and is often mistaken for *A. centripunctata.* The material at the disposal of the writer consists of two complete worms obtained from sheep in Muktesar and some fragments from sheep sent to the writer from the Bombay Presidency and the Punjab. The opportunity is taken to supply a complete description of the worm, offering at the same time some comments on the original description of this worm given by Woodland.

The entire worm is about fifteen feet in length. The maximum breadth of the worm, 2·95 mm., is attained in the hinder portion of the neck region, while the minimum width, 1·72 mm., is in the posteriormost part of the worm.

The scolex is, as usual, a rounded structure and is separated from the neck by a small constriction. It measures 2·08 × 2·42 mm. The four rounded suckers on the scolex have a diameter of 0·95–1·02 mm. The worm is comparatively much thicker than the other species excepting *A. tatia* n.sp. The first indication of strobilation is found in the region behind the neck where it is represented by the appearance of transverse rudiments of the female genitalia. This metamerism does not, however, affect the margin of the body. As the worm is traced posteriorly the genital ducts become more and more prominent. The first trace of external segmentation is noticed under a microscope at a distance of about 30 cm. from the scolex.

The excretory system consists, as usual, of a dorsal and a ventral

excretory canal on each side of the worm. The dorsal excretory canal is internal to the ventral. In the neck region the ventral and the dorsal excretory canals are respectively 0·07 and 0·065 mm. wide. The ventral canal increases in width as it passes posteriorly until in the posteriormost portion of the worm it attains a width of 0·19 mm. The dorsal canal, however, diminishes in width as it passes posteriorly until at last it disappears completely at a distance of about 40 cm. from the scolex.

The two stout lateral nerves pass longitudinally along the entire length of the worm. They are situated between the margins of the body and the ventral excretory canal, being disposed somewhat closer to the latter.

The musculature consists of the usual transverse muscles surrounding the medullary portion. In addition to these there is a very thick layer of longitudinal muscles immediately outside the transverse muscles. At a small distance underneath the outer cuticle there is a development of a thin layer of longitudinal muscles which is not uniformly developed throughout the strobila. Its thickness varies to some extent in different regions of the strobila.

The male genitalia consist of the testes the rudiments of which are seen at a distance of about 5 cm. from the scolex. As is typical of the genus, they are disposed in four columns, one on either side of the ventral excretory vessels. As remarked by Woodland, each column is three- to four-testes deep. The cirrus sac lies, as a rule, anterior to the vulva, but in some cases in the immature region they appear to be almost in the same dorso-ventral plane. They may lie dorsal or ventral to the vulva irrespective of the right or the left side. In this respect the observations of the writer differ from those of Woodland who states that in the vast majority of cases the cirrus sacs on the right side are dorsal to the vulvæ while those on the left are ventral to them. The cirrus

Fig. 8. *Avitellina tatia* n.sp., a portion of gravid strobila showing pear-shaped paruterine organs. × 26·6.

Fig. 9. *Avitellina chalmersi*, scolex. × 26·6.

Fig. 10, 11, 12, 13. *Avitellina chalmersi*, various shapes of paruterine organs. × 53·3.

Fig. 14. *Avitellina chalmersi*, longitudinal section of gravid proglottides. × 26·6.

Fig. 15. *Avitellina lahorea*, gravid proglottides. × 26·6.

Fig. 16. *Avitellina lahorea*, scolex. × 26·6.

Fig. 17. *Avitellina sudanea*, scolex. × 26·6.

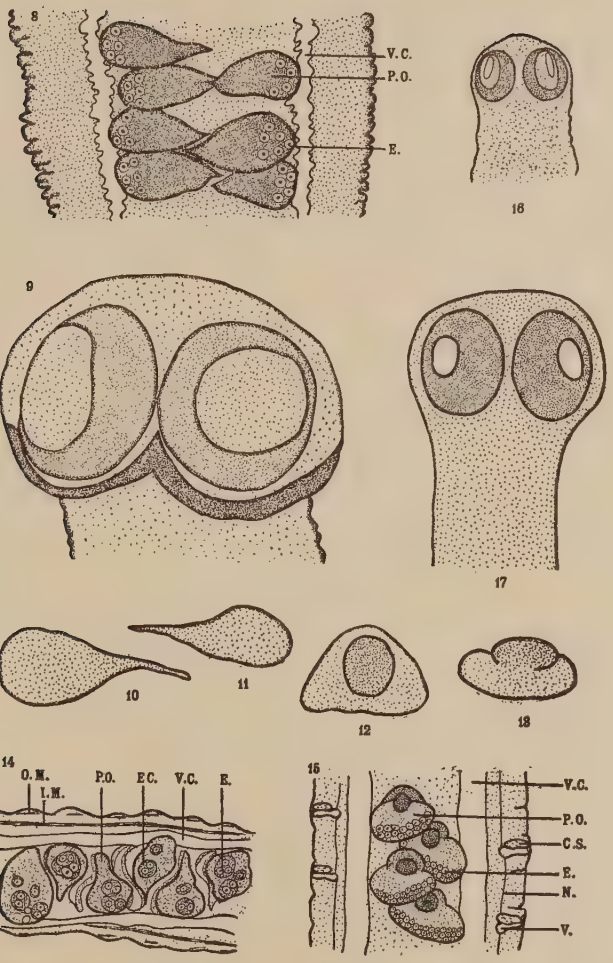


Fig. 8. *Avitellina tatia* n.sp. Figs. 9-14. *Avitellina chalmersi.*
Figs. 15-16. *Avitellina lahorea.* Fig. 17. *Avitellina sudanea*

[For explanation of abbreviations see pp. 161–162]

is enclosed inside the cirrus sac, but it is not a very prominent structure. The vas deferens is slightly wavy. The cirrus sac measures 0·63–0·72 × 0·14–0·22 mm. and is distinctly smaller than the vulva. The genital pores are irregularly alternate and stand out prominently on the margin as remarked by Woodland.

The development of the female genitalia has not been satisfactorily worked out in this genus. The excellent material at the disposal of the writer has enabled him to study this in detail. The first rudiment of the female genitalia appears as a centrally running mass which is deeply stained. It originates at a very short distance behind the scolex. At a distance of 7 to 8 cm. from the scolex the centrally running mass breaks up into fine transverse tubules. These tubules grow somewhat wider posteriorly. In the beginning all the tubules appear to lie in a single central line, but soon they alternate with each other. These alternating tubules then migrate some distance laterally and arrange themselves into two separate rows, leaving a clear central area. In connection with the inner ends of these tubules develops a small knob which gradually separates from it and forms the ovary. Simultaneously with this, rudiments of the uterine tubules appear in the central line which become associated and continuous with the genital tubules referred to above. With the separation of the ovary from the genital duct a connection between these two is established by an oviduct which elongates more and more and ultimately forms a loop. The female genital duct, which may now be called the vagina, becomes more and more elongated laterally. Its terminal portion gets more specialised and forms the vulva which subsequently becomes surrounded by the glandular cells. The genital pore which is irregularly alternate does not make its appearance until the vulva is well formed. It does not arise at the margin of the body, as might be expected, but appears as a tiny opening at a small distance from the margin. It is only by the secondary growth that they become associated with the margin of the strobila. The receptaculum seminis arises as a small enlargement of the vagina which later dilates more and more. At a distance of about 28 cm. from the scolex the ovaries commence degenerating and the uterine tubules grow wider and wider. The testes do not, however, begin to degenerate in this region, but the process of degeneration affect them about 5 cm. behind this region. The uteri ultimately become sac-like and develop a bladder in connection

with their anterior face. With the development of the bladder the process of the formation of the paruterine organ is complete. The mature paruterine organ measures about 0·425×0·2 mm. and is pear-shaped and alternating. It occupies more space antero-posteriorly than the width of its own segment. The paruterine organs in some cases appear as mere sacs instead of pear-shaped, while in others the pears become so much elongated that they appear as clubs. The gravid segments show only the ventral excretory canals and the central mass of alternating pear-shaped paruterine organs. Each paruterine organ contains about five to six egg capsules. The eggs measure about 0·021–0·024 mm. in diameter.

Avitellina lahorea Woodland, 1927. (Figs. 15-16)

This species was originally described by Woodland (1927) and his description was based on two pieces of strobila, one immature and the other male mature, presumed to have been obtained either from a sheep, a goat or some other ruminant. The description of Woodland, based as it is on the observation on only two fragments, is by no means complete. The writer had an opportunity in 1929 of collecting this species from goats in Nagpur and the present opportunity is taken to supply some additional data in regard to the anatomy of the worm.

The largest piece of strobila obtained measured about six feet, but this is by no means the maximum length of the worm. The greatest width, 0·138 mm., is found in the posterior part of the neck region. The width of the gravid portion is not the minimum as in the other species of the genus. The anterior neck region is the narrowest and measures 0·52 mm. in width.

The scolex is comparatively small and measures 0·42 × 0·57 mm. It is not set off from the rest of the strobila by a deep constriction. The four suckers have a diameter of about 0·3 mm.

The nervous and the excretory systems are quite typical of the genus. The dorsal and the ventral excretory canals measure 0·04 and 0·06 mm. respectively in the posterior part of the neck region.

The male genitalia consist as usual of four columns of testes, one situated on each side of the ventral excretory canals. Woodland (1927) states that the outer column of testes is only one-testis deep. This is no doubt the rule, but in some regions of the strobila the outer column

of testes appears to be two-testes deep. This discrepancy in the thickness of the outer column of testes is noticeable in some region even on the different sides of the same region of the strobila. Such variation in regard to the outer column of testes is not restricted to this species only, but is also noticed in *A. sudanea* and *A. tatia* n.sp. The inner column of testes is two- to four-testes deep. The cirrus sac is situated anterior to the vulva. It may lie dorsal or ventral to the latter irrespective of the right or the left side. Here again Woodland's contention, that in the majority of cases the cirrus sac on the right side lies dorsal to the vulva and ventral to it on the left side, does not hold good. It measures 0·107–0·189 × 0·037–0·052 mm. In the immature and the male mature proglottides the cirrus sac is distinctly smaller than the vulva, but in the gravid segments it tends to be almost equal in length to the latter. The vas deferens and the cirrus is as usual.

The female genitalia consist of the ovary measuring 0·063 mm. in diameter. The vulva measures 0·154–0·186 × 0·033–0·037 mm. The receptaculum seminis is 0·06 × 0·03. The relation of the various female genital organs with respect to one another has already been described by Woodland (1927). The uterine ducts alternate with each other irregularly, so do also the genital pores. The mature paruterine organs are snail-shaped as described by Woodland and measure about 0·43 × 0·36 mm. The gravid paruterine organs are somewhat different in shape. The ova measuring 0·025 mm. in diameter accumulate in the posterior part of the paruterine organs.

Avitellina sudanea Woodland, 1927. (Figs. 17, 19-21)

This species was originally described by Woodland (1927) and his description was based on the material obtained from sheep by Dr. A. J. Chalmers in the vicinity of Khartoum. Nagaty (1929) supplied additional data in regard to this parasite from the material which is believed to have come from *Ovis laticauda* in Egypt. This parasite occurs in Nagpur and abundantly so in Muktesar. An attempt was made to obtain and study this parasite as completely as possible. Both Woodland and Nagaty having only fragments of this species of worm at their disposal, the account given by both of these authors is naturally in no way complete. The present opportunity is therefore taken to supply a complete account of the parasite offering at the same time, wherever

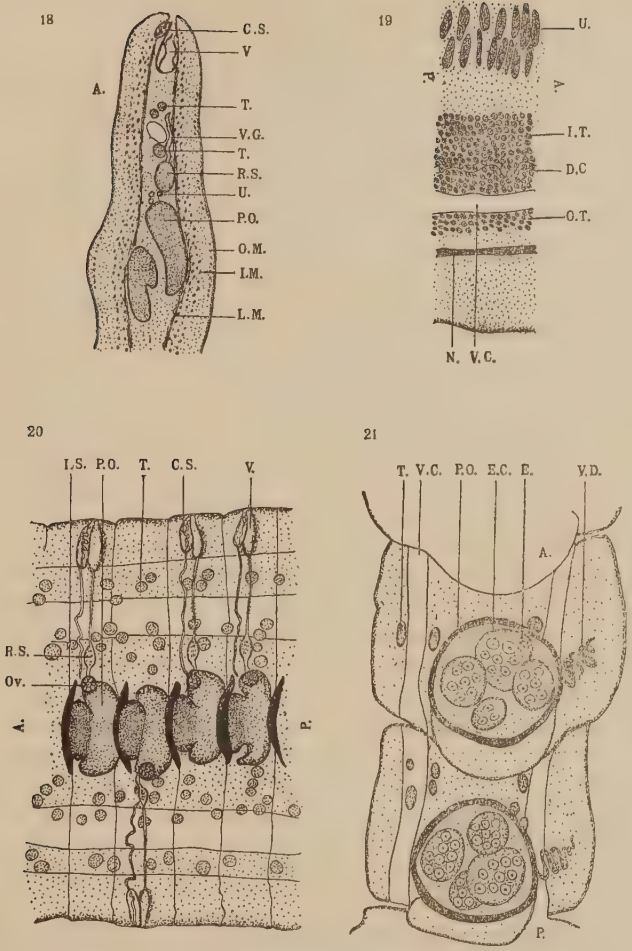


Fig. 18. *Avitellina chalmersi*, transverse section of half proglottis. ×40.
Fig. 19. *Avitellina sudanea*, half portion of immature strobila. ×40.
Fig. 20. *Avitellina sudanea*, mature strobila. ×40.
Fig. 21. *Avitellina sudanea*, two segments ready to be dropped out showing paruterine organ and its contents and traces of vas deferens and testes. ×80.

[For explanation of abbreviations see pp. 161–162]

necessary, a few comments on the description of the worm given by the two previous authors.

The two entire worms collected were about 13 feet long. The maximum width, 2·4 mm., is found in the neck region. The width then diminishes gradually as the worm is traced posteriorly until at last the posterior-most portion is only 0·5 mm. wide.

None of the two previous authors had scolex at their disposal. As in other species of the genus, this is a rounded structure measuring 1·12 × 0·8 mm. approximately. The four suckers on the scolex have a diameter of about 0·62 mm. The scolex is not set off from the rest of the strobila by a deep constriction as in some species. A considerable portion of the strobila following the scolex has a crenulated margin, but this bears no relation to the internal metamerism of the worm. Incipient segmentation occurs with the appearance of the rudiments of the genital ducts and it becomes more and more pronounced posteriorly.

The excretory system consists of a pair of dorsal excretory canals and a pair of ventral excretory canals. The former are internal to the latter. In some specimens the dorsal excretory canals are observed to be more wavy than the ventral ones. As usual the ventral excretory canals acquire more and more width as they pass posteriorly while the dorsal ones diminish in width posteriorly until at last, at a distance of about 20 cm. from the scolex they completely vanish. The width of dorsal and ventral excretory canal, immediately behind the scolex, is 0·05 and 0·065 mm. respectively.

The inner layer of longitudinal muscles is present as described by both Woodland and Nagaty, but Nagaty remarks that the outer thin layer of longitudinal muscles figured by Woodland is not present at all. It is certain that the outer longitudinal layer of muscles is not so distinct as figured by Woodland, neither has it the same continuity as depicted by this author, but at places underneath the cuticle thin muscular fibres are noticed.

The nervous system consists of two stout lateral nerves passing longitudinally on each side, between the margin of the body and the ventral excretory canal, being in closer proximity to the latter.

The male genitalia consists of four columns of testes, one situated on each side of the ventral excretory canals. As stated by Woodland, as a rule, the outer column of testes is one-testis deep, but in places it

appears to be two-testes deep. It is not also unusual to find that the outer column being one-testis deep on one side of the strobila and two-testes deep on the other. As remarked by Nagaty the writer also found the testes in the outer column altogether missing in some regions of the strobila. In regard to the inner column of testes both Woodland and Nagaty have failed to observe its development. This was certainly due to lack of a complete worm at the disposal of both the authors. The possession of two complete worms have enabled the writer to study this point more carefully. To begin with, in the immature region of the strobila, the inner column of testes is about ten-testes deep, but as it is traced posteriorly its depths becomes less and less until in the region of the strobila where the paruterine organs assume a typical kidney-shaped form it becomes only three- to four-testes deep. Another remarkable feature of this species is that traces of testes and vas deferens persist even in the posterior-most segments which have been already dropped out or are ready to be dropped out. The testes in the mature region of the strobila measure about 0·03–0·05 mm. in diameter. The vas deferens is as usual an undulating duct and can be traced, as stated by Nagaty, up to the level of the ovary. The cirrus sac measures 0·12–0·14 × 0·025–0·04 mm. and, as remarked by Nagaty, is either shorter than or equal to the length of the vulva. A large proportion of the vas deferens is enclosed in the cirrus sac and in the gravid region the entire cirrus sac is filled with this duct. For the greater portion of the worm the cirrus sac never extends beyond the lateral nerve, but in the proglottides which are ready to be dropped out they touch the exterior border of the ventral excretory canal.

The ovary was not present in the material described by Woodland, while Nagaty describes it to be kidney-shaped. The observations of the writer indicate that the ovary is not kidney-shaped, but it is round as in other species of the genus. Probably Nagaty's observations were based upon examination of a piece of strobila in which the ovaries had started degenerating or in which they were not completely developed. The ovary is about 0·065 mm. in diameter. The details in regard to the development of the female genitalia are exactly similar to those in *A. chalmersi*. From the ovary emerges a small oviduct which bifurcates into an inner uterine duct and an outer duct, the vagina. All the uterine tubules appear to lie in a single central line,

between the two rows formed by the ovaries. Very soon the uterine tubules alternate with each other irregularly and thus tend to form two distinct lines. The paruterine organs develop in connection with the uteri. In the beginning the uterine tubes with the rudiments of the paruterine organs developed in their connection are disposed alternately, but as the paruterine organs assume their characteristic kidney-shaped form they all lie in a single central line along with the uteri. Interproglottidal sheets are developed gradually. When mature each paruterine organ appears to be kidney-shaped as described by Woodland. As the proglottides become more and more gravid the bladder of the paruterine organ grows larger in size until in the proglottides ready to be dropped the entire paruterine organ assumes a rounded form. Each gravid paruterine organ contains five to six egg capsules containing a few or more ova according to their size. The mature paruterine organs measure 0·33–0·37 × 0·2–0·23 mm., while the gravid ones measure 0·23–0·24 mm. in diameter. The ova measure 0·04–0·06 mm. in diameter. The vulva is invariably larger than the cirrus sac, but in some cases may be equal to it. It lies posterior to the cirrus sac and measures 0·14–0·19 × 0·03–0·045 mm. It may lie either dorsal or ventral to the cirrus sac irrespective of the right or the left side. Here again Woodland's contention does not hold good. The receptaculum seminis is, as a rule, oval and not rounded as remarked by Woodland. It measures approximately 0·1 × 0·04 mm.

With a view to facilitate ready identification of the existing species of *Avitellina* the key published by Nagaty (1929) has been enlarged and modified as follows :—

Key to the species of *Avitellina*

1.	Cirrus sac longer than vulva	2
	Cirrus sac smaller than vulva	3
2.	Cirrus sac at the most twice as long as the vulva, outer column of testes one- or two-testes deep	*A. tatia*
	Cirrus sac three or more times longer than vulva, outer column of testes three- to four-testes deep	*A. woodlandi*
3.	Dorsal excretory canals internal to the ventral excretory canals	5
	Dorsal excretory canals external to ventral excretory canals	4
4.	Some testes lateral to dorsal excretory vessels... ...	*A. pintneri*
	No testes lateral to dorsal excretory vessels	*A. ægyptiaca*

5.	Outer column of testes as a rule one-testis deep ...	6
	Outer column of testes as a rule more than one-testis deep	7
6.	Mature paruterine organs kidney-shaped	*A. sudanea*
	Mature paruterine organs snail-shaped	*A. lahorea*
7.	Mature paruterine organs banana-shaped	*A. goughi*
	Mature paruterine organs pear- or sac-shaped... ...	8
8.	A row of testes external to nerve cord	*A. southwelli*
	No testes external to nerve cord	9
9.	Outer column of testes about two-testes deep, genital apertures situated on a thickening	*A. chalmersi*
	Outer column of testes two- to three-testes deep, genital apertures not situated on a thickening	*A. centripunctata*

Summary.

Two new species of *Avitellina*, *A. woodlandi* and *A. tatia*, have been described and separated from the allied species of the genus. Both these species are remarkable for having cirrus sac longer than vulva.

Additional data are provided in regard to the structure of the species *A. sudanea*, *A. lahorea* and *A. chalmersi*.

The development of the female genitalia of *A. chalmersi*, which may be regarded as typical of the genus, has been given in detail for the first time.

New observations on the development of the inner column of testes in *A. sudanea* are made.

A review of the existing species of *Avitellina* has been taken and a key to all the known species of the genus has been given.

Explanation of Abbreviations.

A.	Anterior aspect.
C.	Cirrus.
C.S.	Cirrus sac.
D.C.	Dorsal excretory canal.
E.	Egg.
E.C.	Egg capsule.
G.A.	Genital atrium.
G.V.	Glands surrounding vulva.
I.T.	Inner column of testes.
I.M.	Inner layer of longitudinal muscles.
I.S.	Interproglottidal sheets of connective tissue.
L.M.	Layer of transverse muscles.
N.	nerve.
O.T.	Outer column of testes.
O.M.	Outer layer of longitudinal muscles.

OV.	Ovary.
P.G.	Prostate glands.
P.	Posterior aspect.
P.O.	paruterine organ.
R.S.	Receptaculum seminis.
T.	Testis.
U.	Uterus.
V.	Vulva.
V.G.	Vagina.
V.C.	Ventral excretory canal.
V.D.	Vas deferens.

Acknowledgments.

The writer wishes here to record his gratefulness to Professor R. T. Leiper, F.R.S., under whose supervision the whole of this work has been completed. He also desires to express his indebtedness to Messrs. R. N. Naik and P. S. Nair for the specimens from Bombay and Nagpur respectively.

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Journal of Helminthology, Vol. XIV, *No.* 3, *September,* 1936, *pp.* 163–180.

Studies on the Helminths of India. Trematoda I.

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TREMATODA

Dicrocœliidæ Odhner, 1911.

Eurytrema Looss, 1907.

Eurytrema pancreaticum (Janson, 1889) Looss, 1907. (Figs. 1-5)

The material studied was collected from three different localities in India. It consists of large-sized worms collected by Mr. M. R. Mahajan, M.R.C.V.S., from the pancreatic ducts of a cow in Hyderabad (Deccan), very small worms collected by the writer from the pancreatic ducts of a cow at Barrackpore and medium-sized flukes collected by Mr. M. B. Menon, G.B.V.C., from the pancreatic ducts of a cow at Kalimpong, Bengal. The writer wishes here to express his indebtedness to Messrs. M. R. Mahajan and M. B. Menon, Veterinary Investigation Officers for Hyderabad (Deccan) and Bengal respectively.

The large specimens from Hyderabad measure 9-12·5 mm. in length and 5-8 mm. in breadth and resemble to a large extent the material from China and Japan described by Looss (1907). The caudal appendage was very distinct in some cases while in others it was less prominent. The oral sucker was distinctly larger than the ventral. The former measured 1·3-1·63 mm. and the latter 0·885-1·37 mm. The eggs measured 0·029-0·031 × 0·04-0·043 mm. The cirrus sac was in all cases found to be terminating anteriorly to the ventral sucker and not resting on this organ as described by Looss. The testes were in some cases lobed while in others they had an entire margin. Even in the same individual one of the testes was lobed and the other was found to be entire. The ovary showed either quite distinct lobes or was very faintly lobulated. The vitellaria are arranged in groups and these latter lie either close together or spread over a larger area. Their extent shows great variation.

The examination of this material revealed that the only point that is constant is the larger size of the oral sucker than the ventral sucker.

The other differences between this species and *E. cœlomaticum* belong to the category of individual variations. In the opinion of the writer the relative size of the suckers alone should not form a valid basis for the separation of one species from the other.

The material from Bengal was quite plentiful and was remarkable in some respects to which reference will be made presently. The entire material could, with a naked eye, be divided into three categories : the large flukes, the medium flukes and the small flukes. The large specimens were of two different kinds, half of them being pinkish and the other half being completely black in colour. On microscopic examination all of the dark specimens were found to have undergone degeneration of structure, particularly in respect of the essential genital organs. The large specimens were lanceolate in shape and did not possess a very distinct caudal appendage. The medium as well as the small forms had a broader body. The medium sized specimens had a tendency to have an elongated anterior portion of the body and a pronounced triangular appendage posteriorly. In the small forms the anterior end was conical and the triangular caudal appendage was very distinct in some and less so in others.

The large and the small forms appear so different from one another that on cursory examination one is inclined to regard them as different species and this belief is strengthened by the fact that even the smallest forms are sexually quite mature and possess a distinct uterus laden with a large number of ova. But a thorough critical examination of both these together with the intermediate forms reveals that in all these three forms we are dealing with one and the same species. These variations in the form of body and internal anatomy are by no means uncommon in the members of the family Dicrocœliidæ. Dollfus (1922) pointed out variations in the species *Dicrocœlium dendriticum* and Ware (1923) did so in the case of *Patynosomum fastosum* and *Eurytrema pancreaticum*. This latter species as described by Looss (1907) and Railliet and Marotel (1898) has testes with moderately developed lobes. Ware (1923) while examining a large number of specimens of this species came across a variety with very deeply lobed testes and curiously the material at the disposal of the writer, which, as remarked previously, came from Bengal, consists entirely of individuals with deeply lobed testes. This variety of *E. pancreaticum* appears therefore to be very rare and is remarkable in

so far as it shows considerable variations in regard to most of the internal as well as the external features of the anatomy. The present opportunity is therefore taken to record detailed observations on this rare variety and to point out the innumerable variations of structure to which it is subject.

Variations in regard to the shape of the body have already been pointed out previously. In the smaller forms the body may occasionally be broader than long. The cuticle is smooth in all cases. The medium and the smaller forms show some folds in the margin of their body. The musculature is poor in all cases. The mouth is subterminal. The oral sucker in the small and the medium forms is circular while in the large forms it is oval. The ventral sucker is circular and larger than the oral in all the forms. The pharynx is oval in all cases. The œsophagus is either straight or has a tendency to bend in the middle of its course. The intestinal cæca are sinuous in all cases.

The excretory system is quite typical of the genus and conforms to that described by the writer (Bhalerao, 1924) in *E. dajii*.

The genital pore is close behind the intestinal bifurcation in all the cases. The testes in both the cases are deeply lobed and occupy a larger area in the body and have a tendency to lie closer to each other than in the typical *E. pancreaticum*. In some cases the lobes are comparatively few and less deep. The lobes in others are so deep as to give them an appearance of a branched structure. In some, particularly in the smaller forms, the testes have a tendency to lie more in the zone of the ventral sucker, but in the larger forms they lie for the greater part posterior to the ventral sucker. In one instance all the lobes of the testes were noticed to be directed towards the sides of the body, radiating from its centre near the ventral sucker.

The cirrus sac in both the forms is oblique and disposed, in the majority of cases, towards the right side and in a few instances towards the left. In the smaller forms it either rests on the ventral sucker or partially overlaps it. In the large forms it does not rest on the ventral sucker, but it's posterior portion lies by the side of the ventral sucker. In the medium sized specimens either of these conditions may be observed. The contents of the cirrus sac in all cases are the same. Occupying a considerable portion of the cirrus sac is a coiled vesicula seminalis filled with spermatozoa. The vesicula seminalis is followed by a short pars

prostatica surrounded with unicellular prostatic glands. The terminal portion of the male genital duct is the eversible, muscular cirrus.

The ovary is lobed and the lobes vary from three to eight. The depth of the lobes is subject to great variation. In some of the smaller forms it shows only small protuberances while in others and in almost all the large and medium forms the lobes of the ovary are deep. The ovary may be situated either to the right or to the left of the central line. It has been observed that it possesses a predilection for the side towards which the cirrus sac is deflected. The position of the receptaculum seminis with respect to the ovary is subject to some variations in all the forms. It may either overlap the ovary or lie centrally to its side. The uterus has the same disposition in all the forms and it is quite typical.

The vitellaria are, in all cases, follicular and extend on each side of the body exterior to the intestinal cæca. Occasionally a few follicles overlap the intestinal cæca or appear in the intracæcal area. The follicles appear either to be arranged in definite groups or disposed in one continuous mass. Their length and posterior extension are subject to variations. The number of groups of vitelline follicles is not also constant.

Measurements of some organs of the small and the large forms are given below in a tabular form.

	Small forms	Large forms
Length	1·7–2·45 mm.	3–3·6 mm.
Breadth	1·9–2·65 mm.	2·66–3·9 mm.
Oral sucker	0·33 mm. diameter	0·705–0·740 × 0·415–0·615 mm.
Ventral sucker ...	0·485 mm. diameter	0·66–0·90 mm. diameter
The ratio between the oral and the ventral sucker	2 : 3	2 : 3
Pharynx	0·16 × 0·12 mm.	0·225–0·300 × 0·199–0·260 mm.
Œsophagus	0·045 mm. long	0·35 mm. long
Cæca from posterior end	0·63 mm.	1·06–1·5 mm.
Testes	0·5 × 0·54 mm.	1·15–1·49 × 0·7–1·2 mm.
Cirrus sac	0·39 × 0·13 mm.	0·815–1·12 × 0·2–0·325 mm.
Ovary	0·225 × 0·135 mm.	0·515–0·735 × 0·44–0·60 mm.
Receptaculum seminis	0·16 × 0·11 mm.	0·22 × 0·20 mm.
Shell gland	0·175 × 0·12 mm.	0·32–0·38 × 0·33–0·48 mm.
Ova	0·039–0·041 × 0·022–0·028 mm.	0·038–0·048 × 0·0275–0·032 mm.

It will be seen from the foregoing remarks that the smaller and the larger forms from the pancreatic ducts of a cow in Bengal do not differ

from one another except in size of the body and the disposition of the cirrus sac with respect to the ventral sucker, but this latter feature is subject to much variation which will be apparent if a comparison is made of the figures of *E. pancreaticum* given previously by various authors. In the figure given by Railliet and Marotel (1898) it is shown lying by the side of the ventral sucker, while Looss (1907) depicts it to be resting on that organ. Ware (1923) who made a detailed study of this species figured both the conditions. It is therefore quite certain that the smaller individuals are comparatively younger in age than the bigger ones, but both of them belong to the same species of *Eurytrema.*

Now on comparing these specimens with *E. pancreaticum* it is found that the only reliable difference between the two is the nature of the testes. No other features which distinguish these forms from *E. pancreaticum* are of a constant nature. It is therefore considered to regard these specimens as a mere variety of *E. pancreaticum.* It may be remarked here that the writer failed to find any individual in the collection from Bengal which possessed large sized suckers as in the case of typical *E. pancreaticum.*

Discussion on the genus Eurytrema.—Up to the present moment nearly twenty-one species have been proposed under the genus *Eurytrema.* Of these, Kossack (1910) proposed the inclusion of *E. crucifer* Nicoll, 1914, in his newly created genus *Paradistomum.* Travassos (1916) proposed the new genus *Infidum* for the species *E. infidum* Faria, 1910. Dollfus (1922) considered that the species *E. cœlomaticum* (Giard & Billet, 1892) to be the same as *E. pancreaticum* (Janson, 1889). This latter statement has been corroborated by Ware (1923). Yamaguti (1933) regards *E. satoi* Kobayashi, 1915 a synonym of *E. pancreaticum.* The remaining seventeen species, which have up to the present moment been considered as valid species, fall into five natural groups and these groups are so different from one another that it is considered necessary here to regard them as different subgenera of *Eurytrema.*

At the outset let us consider the *Pancreaticum* group which we shall regard as the subgenus *Pancreaticum* and which is characterised by having cirrus sac and genital pore posterior to intestinal fork, the major portion of uterine coils being confined to the post-testicular area and vitellaria never extending anterior to testes. To this group belong the species *E. pancreaticum* (Janson, 1889), *E. parvum* (Senoo, 1907), *E. ovis*

Tubangui, 1925, *E. dajii* Bhalerao, 1924 and very probably the species *E. rebelle* Railliet, 1924. Of these species the description of *E. rebelle* has not been adequately given and the species *E. ovis* Tubangui, 1925 is, in the opinion of the writer, synonymous with *E. pancreaticum* from which it differs only in minor respects.

Another group for which the nomenclature of Travassos (1919) may be retained, the subgenus *Lubens* is characterised by the presence of cirrus sac and genital pore anterior to intestinal fork, uterus occupying three-fourths of the body space, vitellaria extending to nearly one-half or more of body length and testes and ventral sucker being much nearer the anterior end. To this group belong the species *E. lubens* (Braun, 1901), *E. polymorphum* Travassos, 1919, *E. intermedium* Travassos, 1919, *E. robustum* Travassos, 1919, and *E. cuyabai* Travassos, 1922. A critical review of these five species convinces us that the species *E. robustum* is a synonym of *E. lubens*, and that *E. cuyabai* is synonymous with *E. intermedium*.

The third group which we shall designate as the subgenus *Concinnum* is characterised by genital pore being anterior to intestinal fork, vitelline follicles being very few and uterus having transverse coils anterior to ventral sucker. To this subgenus belong the species *E. concinnum* (Braun, 1901), *E. brumpti* Railliet, Henry & Joyeux, 1912 and *E. parvum* Travassos, 1916. Of these three the species *parvum* Senoo, 1907 is a homonym being pre-occupied in the genus *Eurytrema*. The writer therefore proposes the name *E. travassosi* for the species *E. parvum* Travassos, 1916.

The fourth group which may be regarded as the subgenus *Conspicum* is characterised by genital pore being anterior to intestinal fork, uterus being confined to posterior half of body, vitellaria occupying nearly half the body length and ventral sucker being comparatively larger. This subgenus contains only two species : *E. conspicum* de Faria, 1912 and *E. pulchrum* Travassos, 1919.

The last group consisting of the species *E. skrjabini* Isaitschikow, 1920 and *E. koschewnikowi* Skrjabin & Massino, 1925, may be designated as the subgenus *Skrjabinus*. It is characterised by genital pore being posterior to intestinal bifurcation, uterine coils occupying evenly the anterior as well as the posterior part of body and ovary being distinctly larger than testes.

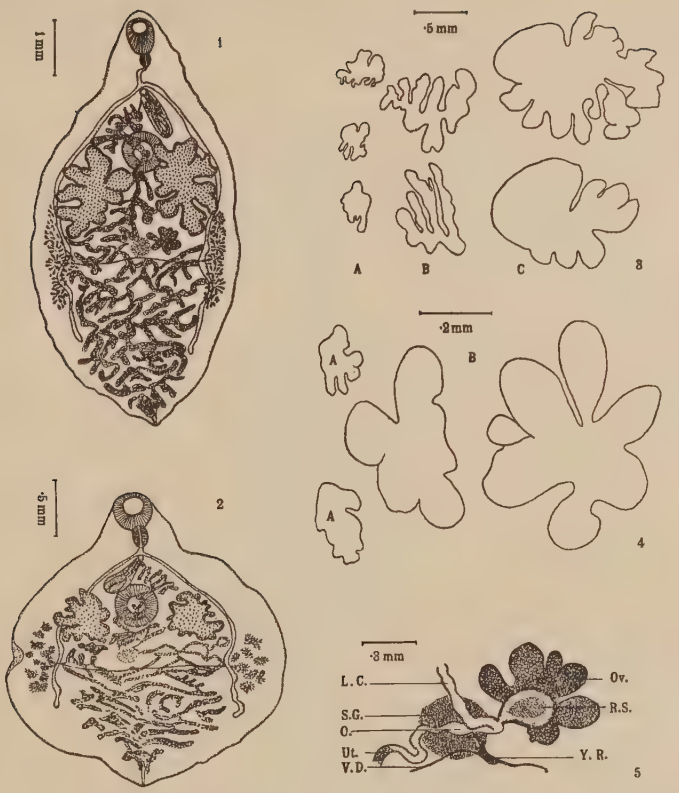

Fig. 1. Dorsal view of *Eurytrema pancreaticum* with deeply lobed testes, large form.

Fig. 2. Dorsal view of *Eurytrema pancreaticum* with deeply lobed testes, small form.

Fig. 3. *Eurytrema pancreaticum* showing various sizes and grades of lobulation of testes : A. Testes of small forms ; B. Testes of medium forms ; C. Testes of large forms.

Fig. 4. *Eurytrema pancreaticum* showing various sizes and grades of lobulation of ovary : A. Ovaries of small form ; B. Ovaries of large forms.

Fig. 5. Dorsal view of the female genitalia of *Eurytrema pancreaticum* with deeply lobed testes : L.C., Laurer's Canal ; ov., Ovary ; O., Ootype ; R. S., Receptaculum seminis ; S. G., shell gland ; ut., Uterus ; V. D., Vitelline duct ; y. r., Yolk reservoir.

These five subgenera may be distinguished from each other with the help of the following key.

Key to the Subgenera of *Eurytrema*.

1.	Ovary larger than testes	*Skrjabinus*
	Ovary smaller than testes	2
2.	Genital pore posterior to or at intestinal fork	*Pancreaticum*
	Genital pore anterior to intestinal fork	3
3.	Uterus occupying much more than half the body space ...	*Lubens*
	Uterus occupying only about half the body space	4
4.	Vitellaria with a few follicles	*Concinnum*
	Vitellaria occupying more than one-third the body length...	*Conspicum*

Paradistomum Kossack, 1910

Paradistomum moghei n.sp. (Fig. 6).

Through the courtesy of Professor M. A. Moghe, of the College of Science, Nagphur, a few mounted specimens from the liver of *Calotes versicolor* were available for study. The specimens were presumably encapsuled in the liver tissue.

The worms are elongated with a conical anterior end and a rounded posterior extremity. Except for the conical anterior portion and a short posterior portion they are more or less of a uniform breadth. They measure 2·3-2·7 mm. in length and the maximum breadth which is attained some distance posterior to the ovary is 0·65-0·75 mm. The cuticle is smooth and is completely devoid of any armature. The musculature is very poor.

The mouth is situated at the extreme anterior end and is surrounded by an almost round oral sucker measuring about 0·22 mm. in diameter. The prepharynx is absent. The oral sucker is followed immediately by an almost globular muscular pharynx measuring about 0·075 mm. in diameter. The œsophagus is very short and measures about 0·04 mm. in length. It divides into two intestinal cæca which are extraordinarily broad and pass posteriorly almost to the extremity of the body. At places the contents of the intestinal cæca are visible as dark masses. The circular ventral sucker is situated at about the fourth of the body length from the anterior end. It is slightly larger than the oral sucker and measures 0·24 mm. in diameter.

Much of the excretory system could not be seen on account of the posterior extension of the intestinal cæca. The excretory pore is situated at the extreme posterior end. It leads by a short canal into an

enlarged bladder which is elongated and extends anteriorly to a short distance behind the ovary.

Fig. 6. *Paradistomum moghei*, n.sp. ventral view.

The male genitalia consist of the testes which are oval and somewhat irregular in outline. They are symmetrical and lie on either side of the body immediately posterior to the ventral sucker. They measure 0·2 × 0·13 mm. The vasa efferentia could not be seen. The cirrus sac, measuring 0·205 × 0·1 mm., is cylindrical and lies a short distance anterior to the ventral sucker. The genital pore is immediately posterior to the œsophagus. At the base of the cirrus sac is the vesicula seminalis measuring 0·085 × 0·035 mm. The vesicula seminalis is followed by the

pars prostatica about 0·09 mm. long. In the beginning the pars prostatica is somewhat constricted. The terminal portion of the male genital duct is the cirrus which is muscular and measures 0·16 × 0·04 mm. It is often seen excerted.

The female genitalia consist of the ovary measuring about 0·12 × 0·115 mm. It is slightly lobed and is situated a little to the right of the middle line. The oval receptaculum seminis is invariably overlapping the ovary and measures 0·13 × 0·08 mm. The shell gland is in the centre of the body. The uterine coils are not very numerous. They describe an irregular U on each side. Ultimately the uterus passes between the ovary and the left testis and opens into the genital atrium. The vitellaria are poorly developed and occupy longitudinally nearly 0·55 mm. in the central portion of the body. They are extracæcal and start from the level of the anterior border of the testes. The transverse vitelline ducts are seen immediately behind the level of the ovary where they meet and form the yolk reservoir. The eggs are small, operculated, dark brown and measure 0·038–0·041 × 0·026–0·027 mm.

It will be evident from the description of the worm that it belongs to the genus *Paradistomum*. This genus was proposed by Kossack (1910) to include the species *Distomum mutabile* Molin, 1859 and his own species *Paradistomum rabusculum*. Later Dollfus (1922) included in this genus *Eurytrema crucifer* Nicoll, 1914 on account of the vitellaria with large follicles along with the species *Cephalogonimus trachysauri* described by MacCallum (1921) and emended the definition of the genus. Recently Johnston (1932) proposed the name *Paradistomum maccallumi* for *Cephalogonimus trachysauri* MacCallum, 1921. Dollfus (1923) proposed provisionally the name *Paradistomum ceratophoræ* for the parasite from the gall bladder of *Ceratophora stoddarti* described and figured by Looss (1908). Quite recently Fernando (1932) gave a fuller description of this very parasite obtained from the same host and named it *Paradistomum lanka*. Fernando's paper is published in the volume 17 of "Spolia zeylanica (B)" and the editor of this journal remarks in a foot-note that because Mr. Fernando has given a full description of this form for the first time the name proposed by him (Fernando), *P. lanka*, should replace *P. ceratophoræ* Dollfus, 1923. This proposal is contrary to the International Code of Zoological Nomenclature. For this reason the correct name of the parasite from the gall-bladder of *Ceratophora*

stoddarti is *Paradistomum ceratophoræ* Dollfus, 1923. Travassos (1919) described *P. magnum* and *P. lutzi*. Tubangui (1928) described a parasite named *P. magnum* from the gall-bladder of *Hemidactylus frenatus*, but being informed by Stiles that this specific name is a homonym he (Tubangui, 1929) proposed the name *P. gregarium* for the same parasite. Narain and Das (1929) described *Dicrocœlium indicum*, and *D. orientalis*, but both these species appropriately belong to the genus *Paradistomum* and not to *Dicrocœlium*. Tubangui (1933) described *P. paloensis* from the gall-bladder of *Hydrosaurus pestulosus*. The writer (Bhalerao, 1929) described *P. geckonum* from the intestine of *Gecko verticillatus* in Rangoon. In the same paper the writer suggested that the genus *Paradistomum* is divisible into two natural groups : (1) that in which the cirrus sac reaches or partly overlaps the ventral sucker and (2) that in which it terminates much anterior to that organ. In the first group may be included the species *P. mutabile*, *P. rabusculum*, *P. maccallumi* and *P. crucifer* and in the second the species *P. gregarium*, *P. ceratophoræ*, *P. geckonum*, *P. orientalis*, *P. indicum* and *P. paloensis*. The specimen described here belongs to the second group and comes much closer to the species *P. orientalis* Narain & Das, 1929. It can, however, be distinguished from it in the following respects : (1) The general shape and size of the body. (2) The vitellaria do not pass anterior to testes and are about one-fifth of the body length. (3) The intestinal cæca are extremely wide. (4) The contents of the cirrus sac are altogether different. (5) The ovary is to the right of the middle line. (6) The excretory bladder is elongated. (7) Testes are behind the zone of ventral sucker. (8) The ova, in spite of the smaller size of the worms, are distinctly larger. For these reasons it is proposed to regard the worms described here as a new species and designate it *Paradistomum moghei* after Professor M. A. Moghe.

The specific diagnosis of *Paradistomum moghei*.—Body flat, conical anteriorly and rounded posteriorly. Length 2·3–2·7 mm., breadth 0·65–0·75 mm. Oral sucker terminal, 0·22 mm. diameter. Pharynx globular, 0·075 mm. diameter. Ventral sucker slightly larger than the oral sucker, 0·24 mm. diameter. Œsophagus short, 0·04 mm. long. Intestinal cæca very broad, touching or overlapping each other in places. Testes, symmetrical posterior to ventral sucker, oval, 0·2 × 0·13 mm. Genital pore central, immediately posterior to œsophagus.

Cirrus sac cylindrical, 0·205 × 0·1 mm. terminating anterior to ventral sucker. Ovary slightly lobed, lying to the right of the middle line, posterior to testes. Receptaculum seminis oval, 0·13 × 0·08 mm., usually overlapping the ovary. Uterus for the most part posterior to ovary. Excretory bladder elongated. Vitellaria occupying slightly more than one-fifth the body length. Ova, small, dark brown, operculated, measuring 0·038–0·041 × 0·026–0·027 mm.

Host.—*Calotes versicolor.*

Location.—Liver.

Locality.—Nagpur (C.P., India.).

Type slide deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar.

Mesocleum Odhner, 1911.

Mesocœlium leiper n.sp. (Fig. 7).

Only two specimens of this species obtained from the intestine of the common water-snake, *Tropidonotus piscator*, in Rangoon, were available for study. One of the specimens was studied in entire mount and the other in sections. The description given below is based on the sectionized specimen.

The worms are broad, flat with both the extremities rounded, the posterior end being broader than the anterior one. They measure 0·197 mm. in length and the greatest breadth attained at about the posterior third of body is 0·825 mm. The mouth is subterminal and is surrounded by the oral sucker measuring 0·24 × 0·225 mm. Posterior to the oral sucker is the globular muscular pharynx measuring 0·065 mm. in diameter. The œsophagus is very small and measures 0·03 mm. in length. It bifurcates into two intestinal cæca which pass posteriorly along the sides of the body and terminates at a distance of 0·63 mm. from the posterior end. The ventral sucker is circular and measures 0·18 mm. in diameter. The ratio between the two suckers is approximately 4 : 3.

The testes are two round, symmetrical bodies which partially overlap the ventral sucker. They lie almost in the anterior zone of the ventral sucker and measure 0·115–0·125 mm. in diameter. The oval cirrus sac is situated anterior to the ventral sucker and measures 0·095 × 0·035 mm.

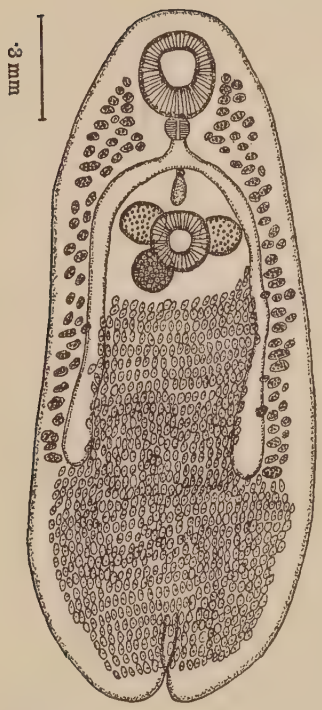

Fig. 7. *Mesocœlium leiperi*, n. sp. ventral view.

The genital pore is situated immediately posterior to the intestinal fork.

The ovary is also round and measures 0·130 mm. in diameter. It is situated on the right side, immediately posterior to the right testis. It also overlaps the ventral sucker posteriorly. The major portion of

the uterine coils lie posterior to the ovary. The vitellaria are follicular and extend from the middle of the oral sucker to the end of the intestinal cæca. They are extra-cæcal. The ova measure 0·038–0·04 × 0·025–0·027 mm.

It will be apparent from the foregoing account that the worms in question belong to the genus *Mesocœlium* proposed by Odhner (1911) for the species from *Bufo melanostictus* described by Lühe (1901) as *Distomum sociale*. Johnston (1912) published three new species of this genus *M. mesembrium*, *M. megaloon* and *M. oligoon*. Nicoll (1914) described *M. micron* from the duodenum of *Hyla cæcila*. André (1915) described *M. carli*. Travassos (1921) added the species *M. incognitum*. Skrjabin (1922) described the species *M. sokolwi* from the intestine of a chameleon. The writer (Bhalerao, 1927) had pointed out the impropriety of assigning this species to the genus *Mesocœlium*. Recently Dollfus (1929) proposed that this species should form a member of the genus *Anchitrema*. Bhalerao (1927) described the species *M. meggitti* from the intestine of *Mabuia dissimilis*. In the year 1929 were described the species *M. monodi* Dollfus, *M. elongatum* Goto & Ozaki and *M. lanceatum* Goto and Ozaki. In the following year were added the species *M. brevicæcum* Ochi, 1930, *M. pearsei* Goto & Ozaki, 1930, *M. japonicum* Goto & Ozaki, 1930 and *M. ovatum* Goto & Ozaki, 1930. Harwood (1932) described the species *M. americanum*. Quite recently Fernando (1933) added *M. burti* and *M. marrsi*. Comparing the species described here with those that have been recorded up to the present moment it is found that it possesses closer affinities to the species *M. monodi* Dollfus, 1929. It, however, differs from it in the even distribution of vitellaria on both sides and in the presence of the genital pore and the cirrus sac posterior to the intestinal fork. For these reasons it is proposed to regard it as a new species for which the name *Mesocœlium leiperi*, after Professor R. T. Leiper, F.R.S., is proposed.

The specific diagnosis of *Mesocœlium leiperi*.—Body broad posteriorly and gradually diminishing in breadth anteriorly. Length 1·97 mm., greatest breadth 0·825 mm. Mouth subterminal. Oral sucker 0·24 × 0·225 mm. Pharynx 0·06 mm. diameter. Œsophagus 0·03 mm. long. Intestinal cæca ending 0·63 mm. from posterior end. Ventral sucker 0·18 mm. diameter. The ratio between the two suckers 4 : 3. Testes round, symmetrical, partially overlapping ventral sucker. Genital

pore immediately posterior to intestinal fork. Cirrus sac anterior to ventral sucker. Ovary round, to the right side, partially overlapping ventral sucker. Uterine coils posterior to ovary. Vitellaria extend from the middle of oral sucker to the ends of intestinal cæca on both sides. Eggs 0·038–0·040 × 0·025–0·027 mm.

Host.—*Tropidonotus piscator.*

Location.—Intestine.

Locality.—Rangoon (Burma).

Type slide deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar.

Mesocœlium sociale (Lühe, 1901) Odhner, 1911.

Only two mounted specimens of this species from the intestine of *Rana tigrina* in Rangoon were forwarded to me by Mr. K. Subramanian, M.A., formerly of the Biological Department, University of Rangoon. This species was first described by Lühe (1901) from *Bufo melanostictus* as *Distomum sociale.* Sewell, 1920 gave a very thorough description of this species obtained from the toad in Calcutta. It has also been recorded from a bufonid host in Dutch East Indies and Paraguay. The writer had on several occasions obtained this parasite from toads in Rangoon, but never did he encounter it in the frog, *Rana tigrina.* Its occurrence therefore in a frog is very interesting. The specimens at the disposal of the writer, although agreed in most respects with those described by Lühe and Sewell, are somewhat larger in size. It is therefore thought necessary to give below measurements of a few organs. In respect of the anterior disposition of the vitellaria and the posterior extension of the intestinal cæca the specimens from the frog in Rangoon agree with those described by Lühe.

Measurements.—Length 2·8–3·5 mm. Maximum breadth 0·7–0·72 mm. Oral sucker 0·275–0·34 × 0·270–0·32 mm. Ventral sucker 0·185–0·22 mm. diameter. Pharynx 0·1–0·139 × 0·065–0·098 mm. Intestinal cæca end 1·06–1·57 mm. from posterior end. Testes 0·17–0·24 × 0·15–0·23 mm. Ovary 0·18–0·225 × 0·17–0·18 mm. Receptaculum seminis 0·071–0·125 × 0·041–0·071 mm. Eggs 0·031–0·033 × 0·02–0·0225 mm.

Summary.

The material of *Eurytrema pancreaticum* from Hyderabad (Deccan) was examined and found to agree with the material of this species from China and Japan, described by Looss (1907) except in the case of cirrus sac which terminates anterior to ventral sucker.

Numerous specimens of the variety of *E. pancreaticum* with deeply lobed testes from the pancreatic ducts of a cow in Bengal were examined and it is found that the smaller and the larger forms belong to the same species. Variations occurring in several organs of this variety have been recorded.

A discussion on the existing species of *Eurytrema* has been evoked and these have been grouped under five subgenera, four of which being new ones.

The species *E. ovis*, *E. robustum* and *E. cuyabai* are considered to be synonyms of *E. pancreaticum*, *E. lubens* and *E. intermedium* respectively.

The species *E. parvum* Travassos, 1916 being a homonym the name *E. travassosi* has been suggested for it.

Paradistomum moghei n.sp. has been described and separated from the existing species of *Paradistomum*.

Mesocœlium leiperi n.sp. has been described and separated from the existing species of *Mesocœlium*.

Mesocœlium sociale has been recorded from *Rana tigrina* and measurements of some of its organs are given.

Acknowledgment.

It is my pleasant duty to express my indebtedness to Professor R. T. Leiper, F.R.S., under whose supervision this work was done.

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Journal of Helminthology, Vol. XIV, *No.* 4, *December*, 1936, *pp.* 181–206.

Studies on the Helminths of India. Trematoda II.

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Ommatobrephidæ Poche, 1925.

In this family is included only one genus *Ommatobrephus* Nicoll, 1914. Originally Nicoll (1914) had placed this genus in the family Lepodermatidæ, but Baer (1924) pointed out that its excretory system being aberrant, it could not be included in that family. Realising the aberrant nature of the excretory system, the very small size of the cirrus sac and the presence of a small number of ova, Poche (1925) created for it the new family. Poche had emphasized the absence of a prepharynx in this family; but, as will be seen from the subsequent remarks, this is not correct.

Ommatobrephus Nicoll, 1914.

Ommatobrephus lobatum Mehra, 1928. (Fig. 1.)

Syn. *O. folium* Thapar & Ali, 1929.

Mehra (1928) had published an account of this parasite in the form of an abstract in the Proceedings of Indian Science Congress, Calcutta. The following year Thapar & Ali (1929) described this very parasite from the intestine of a *Tropidonotus piscator* in Lucknow, naming it *Ommatobrephus folium*. A comparison of the descriptions of Mehra and Thapar & Ali reveals that in both the cases the authors are dealing with one and the same parasite. According to the law of priority therefore the name *O. folium* Thapar & Ali, 1929, falls into the synonymy of *O. lobatum* Mehra, 1928. Later, in 1931, Mehra gave a detailed account of this parasite. The writer has at his disposal several parasites of this species obtained from the intestine of a *Zamenis mucosus* which died in 1930 at the Zoological Gardens, Calcutta. The present opportunity is therefore taken to verify the descriptions of this worm given previously with the help of the material at my disposal.

The specimens at my disposal are somewhat smaller than those of either authors.

Thapar & Ali definitely state that " there is no prepharynx," while Mehra states that " a small prepharynx is easily perceptible." The specimens at my disposal show a definite prepharynx. It is a very small structure and a casual observer is likely to overlook it. The diagram No. 1A gives the relation of the prepharynx to the adjoining organs.

There appears to be a considerable difference of opinion between Mehra and the joint authors in regard to the nature of the excretory bladder. The writer has studied this point carefully in his specimens and he agrees with Mehra in this respect. The statement made by the joint authors that " the excretory system is Y-shaped " and " it exhibits together with its branches a characteristic feature of the family Lepodermatidæ " is entirely erroneous. The excretory system consists of a triangular vesicle which opens behind subterminally by an excretory pore. From the centre of this triangular bladder is given out anteriorly a very small canal which bifurcates into two branches. These latter pass anteriorly, lateral to the ventral sucker, as far as the middle of the pharynx. At this point it becomes thinner and passes posteriorly as far as the level of the ventral sucker where it gives out an anterior and a posterior branch.

In all the adult specimens studied the intestinal cæca are found to be quite in conformity with the descriptions of Mehra and the joint authors. In one sexually immature specimen whose anterior part had undergone some contraction, the intestinal cæca are considerably inflated from about the level of the centre of the ventral sucker to their posterior end. In this specimen the œsophagus is very short with its walls somewhat folded in.

Testes are stated to be lobed by Mehra and also by the joint authors, and on the basis of this nature of the testes the specific name of the parasite proposed by Mehra is based. In five specimens out of seven examined by the writer were the testes distinctly lobed, while in the remaining two they had an entire margin. The latter two specimens probably form a different variety, but the presence in them of testes with entire margin has not been correlated with any other difference of structure. It is therefore suggested that in the genus *Ommatobrephus* the nature of the testes should not in itself be utilized as a basis of separation of one species from the other.

Thapar & Ali state that the left testis is larger than the right. In the specimens studied by the writer the testes were in all cases found

to be unequal, but in the majority of cases the right testis was the larger of the two. Varying as this feature is, it appears to possess no significance.

Thapar & Ali state that "vasa efferentia arise from the anterior end of the testes, but are obliterated owing to the enormous development of the eggs within the uterus." This was found to be the case in a large majority of the specimens studied, but in the specimen with entire testes the writer could trace these ducts as far as the posterior border of the ventral sucker. In this particular instance the uterine coils were not so numerous and they appeared more or less to be bound externally on both sides by the two vasa efferentia.

Thapar & Ali and Mehra differ from each other in regard to the structure of the cirrus sac and its contents. On account of the very small size of the cirrus sac, its nature and its contents it cannot be studied in entire mounts. Recourse had therefore to be made to a set of serial sections of the worm. In the first instance the joint authors describe the cirrus sac to be muscular, but this is far from the fact. As stated by Mehra its walls are composed of parenchymatous cells. This will be evident from the diagram No. 1B of the writer. The vesicula seminalis is a bilobed sac as mentioned by Mehra. It is followed by a short, tubular pars prostatica. The terminal portion of the male genital duct is the cirrus the walls of which possess a distinct musculature. Thapar & Ali have noted this fact, but Mehra contradicts it. In this respect the writer's observations are in conformity with those of the joint authors and not with those of Mehra. In the opinion of Mehra the ductus ejaculatorius is only tubular but not muscular. The question now arises whether the cirrus is protrusible. The writer did not notice the everted condition of the cirrus, but it is quite logical to attribute certain amount of extensibility to a structure possessing musculature. Thapar & Ali, moreover, did not commit themselves by making a definite statement that the cirrus is protrusible. In regard to the prostatic glands Mehra makes a statement that they surround the terminal portion of the vesicula seminalis, the pars prostatica and the ductus ejaculatorius. In the sections studied by the writer the prostatic cells were found surrounding the pars prostatica and a greater portion of the cirrus only. Towards the terminal part of the cirrus the prostatic glands are very rare.

Mehra in his paper remarks that " the account of the connection of

the Laurer's canal with the receptaculum seminis given by these authors (Thapar & Ali) differ from mine." In his description, however, Mehra does not state the actual points in which it differs from that of the joint authors. He fails to mention the exact point where the Laurer's canal opens proximally. So far as the writer is able to make out from his sections he is inclined to support Thapar & Ali in this respect. There exists a definite connection between the Laurer's canal and the receptaculum seminis as described by the joint authors.

A few measurements of the material at the writer's disposal are given here. Length 1·5–2·2.* Maximum breadth 0·525–0·83. The measurements given hereafter refer to a specimen measuring 2·08 × 0·83. Oral sucker 0·215 × 0·185. Prepharynx 0·02 long. Pharynx 0·13 × 0·115. Œsophagus 0·36 long. Ventral sucker 0·435 × 0·35. Intestinal cæca terminate 0·37 from the posterior end. Testes 0·27–0·285 × 0·165–0·19. Cirrus sac 0·135 × 0·075. Ovary 0·065 dia. Eggs 0·07–0·078 × 0·035–0·0425.

ACANTHOSTOMIDÆ Poche, 1925.

ACANTHOSTOMUM Looss, 1899.

This genus was created by Looss in 1899, but the following year he (Looss, 1900) suggested that the generic name *Acanthostomum* be replaced by *Acanthochasmus* since he considered that the former name was preoccupied by the genus of insecta, *Acanthostoma* Krchbr. Poche (1925), however, pointed out that under the Article 19 of the International Code of Zoological Nomenclature the name *Acanthostomum* cannot be regarded as being preoccupied since the insect genus is named *Acanthostoma*. It is therefore not necessary to replace the trematode generic name *Acanthostomum* by *Acanthochasmus*.

Acanthostomum burminis (Bhalerao, 1926).

This species was described by the writer (Bhalerao, 1926) from the intestine of a *Tropidonotus piscator* in Rangoon as *Acanthochasmus burminis*, but since *Acanthochasmus*, as pointed out above, is a synonym of *Acanthostomum*, the correct name of the parasite is *Acanthostomum burminis*. Subsequent to the writer's publication Thapar & Ali (1929) recorded it from the same host in Lucknow. The writer had also obtained this species from the same snake in Nagpur. It appears therefore that this fluke is a very common parasite of *Tropidonotus piscator* throughout the whole of British India.

* All measurements in millimetres.

PLAGIORCHIDÆ Lühe, 1901.

There exists some difference of opinion in regard to the nomenclature of this family. This is dependent on the validity of either the genus *Plagiorchis* Lühe, 1899 or *Lepoderma* Looss, 1899. The account of both these genera was published on the 28th December, 1899, but Braun (1900) pointed out that although both these genera were published on the same day the journal in which the account of *Lepoderma* was given was issued two days later, *viz.*, on the 30th December, 1899. On the basis of this fact Braun regarded *Lepoderma* as a synonym of *Plagiorchis*. This view was also supported by Stiles (1901) who also gave preference to the date of issue of the journal. Odhner (1911), however, gave priority to the name *Lepoderma* because it was bound up with the type species *L. ramlianum* (Looss, 1896) and for this reason created the family Lepodermatidæ to replace Plagiorchidæ. Baer (1924) and Mehra (1931) accepted the views held by Odhner. Poche (1925) and Fuhrmann (1928) who have, in the recent years, contributed a good deal to the systematics of Trematoda differ from Odhner and accept the view held by Braun. Nicoll (1935) while classifying Trematoda in the Vermes Section of the " Zoological Record " for 1935 gives preference to the family name Plagiorchidæ. The only point so far against the acceptance of the generic name *Plagiorchis* is that it is not bound by a type-species. According to the Article 25 of the International Code of Zoological Nomenclature this is not a very significant point in so far as the genus was published long before 31st December, 1930. The availability and hence also the validity of a genus when not bound by the type-species is only affected if it is proposed after 31st December, 1930. In this particular instance the name *Plagiorchis* being published in 1899 and although not bound by the type species is a valid one. Under these circumstances the writer considers that Plagiorchidæ is a valid family name and consequently Lepodermatidæ lapses into its synonymy. Poche (1925) pointed out that Prosthogonimidæ Nicoll, 1924 and Reniferidæ Baer, 1924 are also synonyms of Plagiorchidæ. There exists no difference of opinion in regard to this point.

CEPHALOGONIMINÆ Looss, 1899.

There exists among the systematists some difference of opinion in regard to the fact whether Cephalogoniminæ should be regarded as a

subfamily of Plagiorchidæ or it should have an independent family status. The subfamily Cephalogoniminæ was created by Looss (1899) who included in it the genera *Cephalogonimus* Poirier, 1886 and *Emoleptalea* Looss, 1900. Nicoll (1914) created the family Cephalogonimidæ and included in it the genus *Prosthogonimus* Lühe, 1899 which was placed by Lühe (1909) in his subfamily Prosthogoniminæ along with his genus *Schistogonimus*. Later Nicoll (1924) placed the genus *Cephalogonimus* in the family Prosthogonimidæ the authorship of which he attributed to Lühe although there exists no such record in literature. Nicoll (1926) considers that the family Cephalogonimidæ is a synonym of Prosthogonimidæ, but in this case also one fails to understand why he attributes the authorship of Cephalogonimidæ to Looss. As a matter of fact, both the families Cephalogonimidæ as well as Prosthogonimidæ were created by Nicoll himself. In the recent years the two great systematists on this group, Poche and Fuhrmann accept the family status of Cephalogonimidæ, but Nicoll (1935) appears to have gone back on his views since he included the genus *Cephalogonimus* in the family Plagiorchidæ in the Vermes Section of the " Zoological Record " for 1934. It is therefore proposed here to examine the point of the status of Cephalogonimidæ in some more detail. The outstanding features by which Cephalogonimidæ is distinguished from other allied families, particularly from Plagiorchidæ, are the position of the genital pore at the extreme anterior end of the body and the excretory bladder with side branches. In regard to the former the genera *Ochetosoma* Braun 1901, *Renifer* Pratt, 1902 and *Lechriorchis* Stafford, 1905 have the genital pore quite well near the anterior end, *viz.*, lateral to the pharynx and the cirrus sac in these cases is also much elongated, moreover the genus

Fig. 1. *Ommatobrephus lobatum*. A. Section through anterior region showing prepharynx (p.). B. Section through cirrus sac showing bilobed vesicula seminalis (v. s.). C. Section through cirrus sac showing pars prostatica (p.p.). D. Section through cirrus sac showing muscular cirrus (c.).

Fig. 2. *Cephalogonimus amphiumæ*. Ventral view of four specimens (A, B, C, D) showing variation of structures.

Fig. 3. *Styphlodora nicolli* n.sp. A. Entire worm, dorsal view. B. Cirrus sac with everted cirrus (c.). C. Section showing the disposition of Laurer's canal with respect to receptaculum seminis. L.C., Laurer's canal; R.S., Receptaculum seminis; S.G. Shell gland; T., Testes; T.V.D., Transverse vitelline duct; V., Vitellaria.

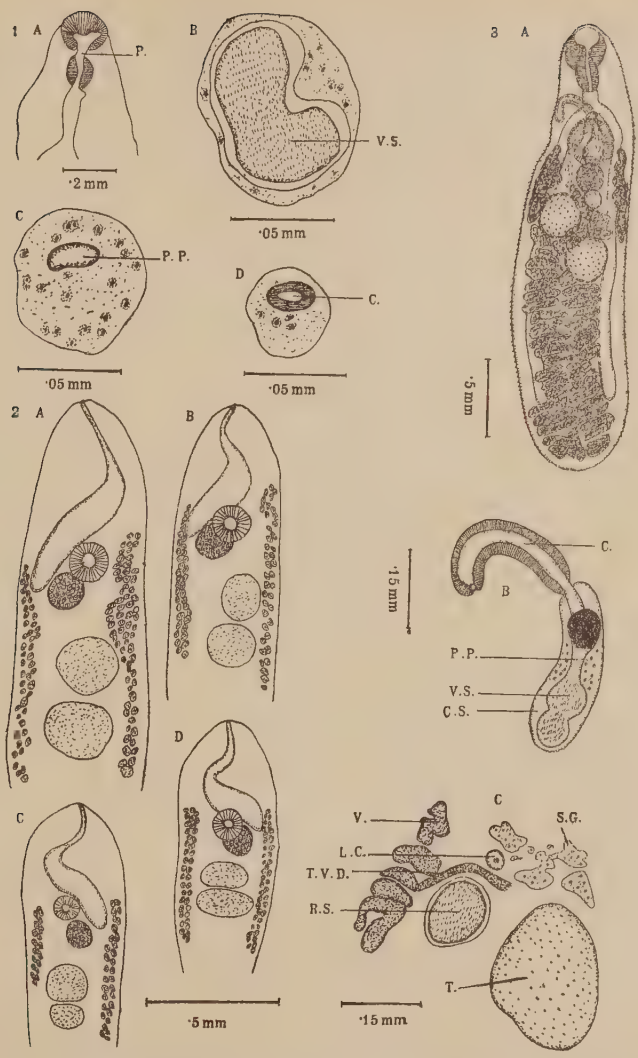

Fig. 1. *Ommatobrephus lobatum* : Fig. 2. *Cephalogonimus amphiumæ* :
Fig. 3. *Styphlodora nicolli* n. sp.

Emoleptalea which is included in Cephalogonimidæ has the genital pore to the side of the oral sucker ; a position intermediate between the two extremes. The presence of lateral branches to the excretory bladder is a character not peculiar to Cephalogonimidæ alone. Many genera in Lepodermatidæ, e.g., *Styphlodora*, *Renifer*, etc., possess the excretory bladder of this type. It is therefore proposed to retain the subfamily status of Cephalogoniminæ as was originally done by Looss (1899) and assign it to the family Plagiorchidæ. Although Sinha (1932) holds a contrary view, Pande (1932) and presumably also Nicoll (1935) support it.

CEPHALOGONIMUS Poirier, 1886.

Cephalogonimus amphiumæ Chandler, 1923 (Fig 2.).

Syn.—*C. magnus* Sinha, 1932

C. gangeticus Pande, 1932.

The genus *Cephalogonimus* was created by Poirier (1886) for the species *C. leonari* obtained from the intestine of the turtle, *Tetrathyra valantii*, in Senegal. To this genus is also referable the species *C. retusum* described by Dujardin (1845) from *Rana temporaria* in Rennes. Subsequently to this about a dozen species of this genus have been described from time to time. Stafford (1902) described *C. americanus* from the intestine of *Rana virescens* and *R. clamata* near Toronto. Blaizot (1910) recorded *C. europæus* from the intestine of *Rana tigrina* in France, but Chandler in (1923) suspected this species as being synonymous with *C. retusum* (Dujardin, 1845) and Travassos (1932) expressed a definite opinion in regard to the synonymy of the former with the latter species. The writer is also in conformity with this view. Nickerson (1912) gave a description of *C. vesicaudus* obtained from the intestine of *Aspidonectes* and *Amyda* from the river Mississippi. The species *C. trachysauri* was recorded by MacCallum, but Chandler (1923) expressed a view that this species "should undoubtedly be placed in a new genus." From this remark it appears that Chandler was evidently unaware of the work of Dollfus (1922) who had already assigned the species *C. trachysauri* to the genus *Paradistomum*. Recently Johnston (1932) proposed that the specific name *C. trachysauri* be replaced by *Paradistomum maccallumi*. Two species from America, *C. amphiumæ and C. compactus* were described by Chandler (1923) and Stunkard (1924) respectively. In the recent years there appeared from India the description of the species *C. emydalis* Moghe, 1930, *C. mehri* Pande, 1932, *C. gangeticus* Pande, 1932 and

C. magnus Sinha, 1932, the first two being from the intestine of *Lissemys punctata* and the latter two from the intestine of *Trionyx gangeticus*. A comparison of the description and the figures of the last two species reveals that both the authors, Sinha and Pande, are dealing with one and the same species and therefore on the law of priority the specific name *C. magnus* Sinha has precedence over the name *C. gangeticus* Pande. Ingles (1932) gave a description of *C. brevicirrus* from the intestine of *Rana aurora* in California.

The writer had obtained in 1926 about a dozen flukes from the intestine of a *Lissemys punctata* (Syn. *Emyda granosa*). On a careful comparison of the material at his disposal with the species recorded previously it is found that the writer's collection is referable to the species *C. amphiumæ* Chandler, 1923. As a result of a careful study it is found that the species *C. amphiumæ* is subject to many variations in regard to the structures that are usually utilized in separating one species of this genus from the other. The present opportunity is therefore taken to record these variations and to examine the validity of some previously described species in the light of these.

The specimens at the disposal of the writer are somewhat smaller than those described by Chandler. The measurements of the various organs will be given in a subsequent part of this communication.

The body in all cases is elliptical, but the region of the greatest breadth varies in different specimens. In some cases, excepting for the extremities which are slightly attenuated, the body of the worms has a uniform width. In some specimens, however, the area of the maximum width is found some distance behind the anterior extremity. In none of the specimens examined was the broadest portion of the body near the posterior end as described by Chandler.

Some authors have utilized the proportion of the body anterior to the ventral sucker to that posterior to it as a point in distinguishing one species of *Cephalogonimus* from the other. In the specimens studied this proportion was found to vary from 4 : 13 to 7 : 26. Roughly speaking the anterior portion of the body is from one-fourth to one-third of the body posterior to the ventral sucker.

Much importance has been given to the presence or absence of the œsophagus. This organ is so minute in some species that it easily escapes the notice of an observer unless the specimens are examined in serial

sections. In none of the specimens examined could this organ be seen in *toto* preparations. Its presence could, however, be easily detected in serial sections. The separation of the species of this genus on the presence or absence of an œsophagus is attended with a considerable amount of risk. It is not unlikely that a re-examination of some species in which the œsophagus has been stated to be absent might reveal in them the presence of that organ.

The shape and the position of the testes have been considered as having some taxonomic importance in this genus. It will be seen from the accompanying diagrams that both these characters are subject to variations. In the figure 2D the testes are seen distinctly elongated in a transverse direction while in figure 2B they show a tendency to be round. The testes in the figures 2A and 2C are forms intermediate between the above two extremes. In regard to the position of the testes in the body it will be seen from figure 2B that they lie almost in the centre of the body : the portion of the body anterior to them being only slightly smaller than the post-testicular portion. The figures 2A, 2D and 2C, however, show an increasingly larger pre-testicular area.

In regard to the shape of receptaculum seminis it is quite correct to distinguish between a round and an oval structure, but an attempt to distinguish an oval from a flask-shaped structure is attended with a considerable amount of risk. Slight variations of the latter type usually do occur on account of the presence of a smaller or a larger number of spermatozoa in this organ.

The accompanying figures show that the form and extent of the cirrus sac is also subject to variations.

Some authors have utilized the lateral or the more central position of the ovary as a criterion to distinguish one species of this genus from the other. In figure 2A it is situated distinctly lateral while in figure 2C it is almost in the centre of the body typically as in the species *C. amphiumæ*. Figures 2B and 2D show stages which are intermediate between these two extremes.

The extent of vitellaria also is subject to much variation. As a rule in this species, as in some others, the gland on the left side is more extensive than that on the right. In an extremely abbreviated condition it extends from the centre of the ventral sucker to the middle of the anterior testis. In an extremely elongated form it is seen to extend from some distance

anterior to the ventral sucker to slightly behind the posterior testis. All stages intermediate between these two extremes do also exist.

In view of the variations that normally occur in *C. amphiumæ* Chandler, 1923 it has been found that the species *Cephalogonimus magnus* Sinha, 1932 can in no way be distinguished from the former species. It has therefore been suggested to regard it a synonym of *C. amphiumæ*, but since *C. gangeticus* is identical with *C. magnus* both these species merge into the synonymy of *C. amphiumæ* Chandler, 1923.

Measurements of *C. amphiumæ* from the intestine of *Lissemys punctata*, Nagpur :—Length 1·1–1·96. Maximum breadth 0·036–0·056. Oral sucker 0·14–0·15 dia. Ventral sucker 0·095–0·13 dia. Pharynx 0·065–0·07 dia. Œsophagus 0·013 long. Testes 0·18–0·255 × 0·09–0·19. Cirrus sac 0·55 × 0·1. Ovary 0·13 × 0·1, 0·165 × 0·145. Receptaculum seminis 0·065–0·080 long. Ova 0·0275–0·036 × 0·13–0·018.

STYPHLOTREMINÆ Baer, 1924.

STYPHLODORA Looss, 1899.

Styphlodora nicolli n.sp. (Fig. 3.).

A few specimens of this new species collected from the intestine of the rat-snake, *Zamenis mucosus*, which died at the Zoological Gardens, Calcutta, were available for study.

The worms are elliptical with the anterior end slightly attenuated and with a broad and round posterior extremity. At the level of the ventral sucker the body is slightly constricted and thus the cephalic portion of the worm can be more or less differentiated from the rest of the body. The entire body of the worm is covered with closely set, backwardly directed scales. At the extreme posterior end the scales are very rare. The worms measure 2·65–2·9 in length and the greatest breadth which is attained at the level of the hinder border of the posterior testis is 0·73–0·8.

The mouth is situated subterminally on the ventral side and is surrounded by an oral sucker measuring 0·27 in diameter. The ventral sucker is situated at one-fourth the length of the body from the anterior end and is slightly larger than the oral sucker. It measures about 0·285 in diameter. The prepharynx is very small and measures 0·045–0·060 in length. The pharynx is oval and very muscular and measures 0·16–0·18 × 0·16–0·165. The œsophagus is small and measures 0·1–0·175 in

length. It is surrounded by numerous unicellular glands. It bifurcates into two intestinal cæca immediately anterior to the ventral sucker. The cæca pass along the sides of the body and terminate at a distance of 0·41–0·56 from the posterior extremity. In some cases the terminal portion of the cæca is slightly swollen and is directed towards the side of the body.

The excretory pore is situated at the extreme posterior end. The excretory bladder is Y-shaped and its stem passes anteriorly as far as the ovary where it bifurcates into two arms.

The male genitalia consist of two entire testes lying obliquely to each other and measuring 0·22–0·335 × 0·27–0·38. The left testis is situated anteriorly. The vasa efferentia arising from their anterior end meet together centrally, slightly behind the cirrus sac and form a vas deferens. The cirrus sac is a straight or slightly curved organ lying dorsally to the ventral sucker and terminating immediately anterior to the ovary. It measures 0·3–0·375 × 0·08–0·10. At the base of the cirrus sac there is a bilobed vesicula seminalis which measures 0·155–0·160 in length. It is followed by a narrow duct, the pars prostatica, measuring 0·03 in the specimen in which the entire genital duct is inside the cirrus sac and 0·08 in which the cirrus is everted out of the cirrus sac. The terminal portion of the male genital duct is the muscular cirrus which is often seen everted out of the cirrus sac. It measures 0·15 × 0·065 in a contracted condition while in a fully extended form it measures 0·385 × 0·06. The genital pore is situated immediately anterior to the ventral sucker, between the latter and the intestinal fork.

The female genitalia consist of an entire and almost round ovary situated immediately posterior to the ventral sucker, slightly to the right of the central line. It measures 0·18–0·19 × 0·165–0·175. The receptaculum seminis is also round and measures 0·130–0·135. It lies dorsal to the ovary, partially overlapping its posterior portion. The Laurer's canal is seen passing anteriorly to the transverse vitelline duct of the right side and opens on the dorsal side of the body above the antero-lateral aspect of the ovary. In several sections the shell gland was found to occupy a central area of 0·23 × 0·1. The uterine coils pass posteriorly between the ovary and the anterior testis and then between the two testes. The coils from the posterior testis to the extreme hinder end are very dense. Some coils overlap the inner border of the intestinal

cæca. Finally the coils are seen between the ovary and the left vitelline gland. The terminal portion of the uterus called the metraterm is very thick and muscular and measures 0·2–0·22 × 0·065–0·08. The vitelline glands are short and compact. The follicles extend from about the level of the middle portion of the ventral sucker to about the level of the second third or the posterior end of the anterior testis. The transverse vitelline ducts pass centrally immediately anterior to the receptaculum seminis. They meet together centrally and form a yolk reservoir. From this latter a small duct leads into the oötype. The eggs are dark brown, operculated and measure 0·0325–0·042 × 0·018–0·022.

The genus *Styphlodora* was proposed by Looss (1899) for his species *S. serrata* and *S. solitaria* from the intestine of *Varanus niloticus* and *Thalassochelys corticata* respectively. Odhner (1911) suggested that the species *Distomum similis* Sonsino, 1890 and *D. horridum* Leidy, 1850 be also included in the genus *Styphlodora*. De Faria (1911) and Goldberger (1911) added the species *S. condita* and *S. bascaniensis* respectively. Nicoll in 1912 described the species *S. najæ* and in 1914 the species *S. persimilis*. MacCallum (1921) described *S. lachesidis* from the intestine of *Lachesis lanceolatus* in Trinidad. Recently Tubangui (1933) gave a description of *S. renalis* from the kidney of *Python reticulatus* in the Philippine Islands. Among these nine species of *Styphlodora* the one described here is closely related to *S. serrata* and *S. condita*, but it can be distinguished from both of these. From the latter it can be differentiated by the extent of the vitellaria and the nature of the testes and their relative position. From the former it can be distinguished by the nature of the testes and the situation of the ventral sucker. It is therefore proposed to regard the species described here as a new one and to designate it *Styphlodora nicolli* after Dr. W. Nicoll.

Specific diagnosis of *Styphlodora nicolli*.—Body elliptical, with anterior end slightly attenuated. Cephalic portion faintly differentiated from the rest of the body. Length 2·65–2·9. Maximum breadth 0·73–0·8. Oral sucker subterminal, 0·27 dia. Prepharynx 0·045–0·060 long. Ventral sucker larger than oral, 0·285 dia., situated at the anterior fourth of body. Œsophagus 0·1–0·175 long. Intestinal cæca terminate at 0·41–0·56 from the posterior end. Testes entire, oblique, 0·22–0·335 × 0·27–0·38. Cirrus sac dorsal to ventral sucker 0·3–0·375 × 0·08–0·1. Vesicula seminalis bilobed. Cirrus eversible. Ovary round, 0·18–0·19 × 0·165–

0·175. Receptaculum seminis round 0·130–0·135. Vitellaria extend from the middle of ventral sucker to about two-third or the posterior end of the anterior testis. Ova 0·0325–0·042 × 0·018–0·022.

Host.—*Zamenis mucosus.*

Location.—Intestine.

Locality.—Calcutta Zoo.

Type slide deposited in the helminthological collection of the Imperial Institute Veterinary Research, Muktesar.

With a view to facilitate a ready identification of the species of *Styphlodora* the following key has been constructed.

Key to the species of *Styphlodora.*

1.	Testes symmetrical or slightly oblique	2
	Testes distinctly oblique, their transverse zones separate	4
2.	Testes symmetrical	*S. solitaria*
	Testes slightly oblique	3
3.	Vitellaria extending posterior to anterior testis	*S. bascaniensis*
	Vitellaria not extending posterior to anterior testis ...	*S. similis*
4.	Prepharynx absent	5
	Prepharynx present	6
5.	Testes with deep lobes	*S. persimilis*
	Testes rounded or slightly lobed	*S. renalis*
6.	Vitellaria ending anterior to testes	*S. najæ*
	Vitellaria present in the testicular zone	7
7.	Vitellaria extending posteriorly as far as the hinder testes	*S. horridum*
	Vitellia extending only as far as the anterior testis ...	8
8.	Vitellaria not extending in the zone of ventral sucker ...	10
	Vitellaria extending in the zone of ventral sucker ...	9
9.	Ventral sucker at one-third the body length from anterior end	*S. serrata*
	Ventral sucker at one-fourth the body length from anterior end	*S. nicolli*
10.	Intestinal cæca ending at one-fourth the body length from posterior end	*S. condita*
	Intestinal cæca ending at one-seventh the body length from posterior end	*S. lachesidis*

Encyclometrinæ Mehra, 1931.

The subfamily Encyclometrinæ was created by Mehra (1931) for the single genus *Encyclometra* which according to him occupies a position intermediate between Plagiorchidæ and Ommatobrephidæ.

ENCYCLOMETRA Baylis & Cannon, 1924.

Encyclometra colubrimurorum (Rud. 1819) Dollfus, 1931.

Dollfus (1931) published the following synonymy of the parasite.

Synonymy.—*Distomum allostomum* Diesing, 1850.
D. caudatum Polonio, 1859.
D. subflacum Sonsino, 1892.
D. sp. no. 1 Timotheev, 1900.
Odhneria bolognensis Baer, 1924.
Paraplagiorchis timotheevi Dollfus, 1924.
Encyclometra bolognensis (Baer, 1924) Baylis & Cannon, 1924.
Orthorchis natritis Modlinger, 1924.

Only one indifferently preserved specimen obtained from the intestine of a *Zamenis mucosus* which died in the Zoological Gardens, Calcutta was available for study, which on examination proved to be *Encyclometra colubrimurorum*. This species was formerly obtained by the writer (Bhalerao, 1926) from the intestine of *Tropidonotus piscator* in Rangoon. Mehra (1931) obtained this parasite from the œsophagus of *Tropidonotus piscator* and the stomach of *Zamenis mucosus* in Allahabad. This fluke therefore appears to be a common parasite of snakes in British India.

PLAGIORCHINÆ Lühe, 1901.

TREMIORCHIS Mehra & Negi, 1926.

Syn. CENTROVITUS Bhalerao, 1926.

Tremiorchis ranarum Mehra & Negi, 1926.

Syn. *Centrovitus pentadelphi* Bhalerao, 1926.

Three tubes of flukes collected by Dr. V. T. Korké, from the intestine of the frog, *Rana tigrina*, in Karnal (Punjab), were available for study. The writer takes this opportunity of thanking Dr. Korké for his kindness in placing the material at his disposal. The flukes on examination proved to be *Tremiorchis ranarum* Mehra & Negi, 1926. The account of this species belonging to a new genus, *Centrovitus pentadelphi*, was published by the writer in " Parasitology " Vol. 18, pp. 154–156. In the same issue of " Parasitology " pp. 168–181, Mehra & Negi gave an account of the same parasite designating it *Tremiorchis ranarum*. Since the paper of Mehra & Negi had reached the press about three weeks

earlier than that of the writer and since they had communicated the paper to the 12th meeting of the Indian Science Congress the joint authors have priority over the writer in regard to the nomenclature of the parasite. *Centrovitus pentadelphi* Bhalerao, 1926 falls therefore into the synonymy of *Tremiorchis ranarum* Mehra & Negi, 1926.

Astiotrema Looss, 1900.

Astiotrema loossi Mehra, 1931. (Fig. 4.).

Amongst about a dozen flukes obtained from the intestine of a *Lissemys punctata* at Nagpur in 1926 only one specimen could be distinguished from others which is referable to the species *Astiotrema loossi* described by Mehra in 1931. Since Mehra had also obtained only one specimen from the intestine of *Kachuga dhongoka* it appears that the infection due to this parasite is usually very slight. The specimen obtained by Mehra being an immature one its description differs in some important respects from the specimen at my disposal. It is therefore proposed here to give a complete description of the adult parasite.

The worm is elliptical with a rounded posterior extremity and slightly attenuated anterior end. It measures 2·76 in length and its maximum breadth which is attained in the region of the anterior testis is 1·625. The cuticle is extremely thin and is completely devoid of any armature.

The mouth is situated slightly behind the anterior extremity and is surrounded by a subterminal oral sucker measuring 0·175 × 0·160. The ventral sucker is situated at two-sevenths the body length from the anterior end and measures 0·26 × 0·20. The ratio existing between the sizes of the oral and the ventral sucker is approximately 3 : 4. A short prepharynx measuring 0·05 is present. The pharynx is globular and muscular and measures 0·8 in diameter. It is not pear-shaped as Mehra described it. The œsophagus is 0·26 long. It bifurcates into two intestinal cæca slightly in front of the ventral sucker. The intestinal cæca pass posteriorly at an appreciable distance from the sides of the body and terminate at varying distance from the posterior extremity.

The nervous system could easily be made out to a large extent. It consists of a transverse nerve band passing on the dorsal aspect of the pharynx at about a third of its length from its anterior border. The nerve band has a triangular ganglion at each end. From each ganglion is

given out a small, comparatively slender nerve, passing towards the anterior end immediately outside the oral sucker and a long and slightly stouter posterior nerve which could be traced posteriorly only as far as the ventral sucker ; it being further obscured by the presence of other organs. Both the nerves give out numerous smaller branches throughout their course.

The excretory system consists of an excretory pore situated ventrally at some distance from the posterior end leading into a Y-shaped bladder.

The male genitalia consist of two testes situated obliquely in the posterior half of the body. Both of them are deeply lobed and look like cauliflowers. In the specimen at my disposal the posterior testis has more lobes than the anterior one and not *vice versa* as Mehra described. The anterior testis is on the left side and touches the intestinal cæcum internally and measures 0·325 × 0·29. The posterior testis is situated on the right side and also touches the intestinal cæcum and measures 0·4 × 0·325. From the centre of each testis is given out a fairly thick vas efferens which passes anteriorly, describing a little curve, and meets centrally, with its companion of the other side, slightly behind the cirrus sac to form a vas deferens which enters the cirrus sac. This latter is a well developed and pear-shaped organ measuring 0·52 × 0·18. Its posterior end is situated centrally at the level of the middle of the ovary. It lies dorsal to the ventral sucker, extending appreciably behind that organ. The base of the cirrus sac is occupied by a bilobed vesicula seminalis, the posterior lobe being smaller than the anterior one. The pars prostatica and the cirrus are comparatively smaller.

The ovary is a somewhat irregularly oval body lying on the right side, at the postero-lateral margin of the cirrus sac, immediately internal to the intestinal cæcum. It measures 0·185 × 0·135. It is not kidney-shaped as described by Mehra and is much smaller in size although the specimen is comparatively more mature. The receptaculum seminis and the Laurer's canal are not small as described by Mehra. The receptaculum seminis is a more or less elliptical structure, lying obliquely between the ovary and the anterior testis much nearer to the former organ. It measures 0·21 × 0·08. The Laurer's canal is slightly larger than half the receptaculum seminis and is situated between this organ and the ovary. The shell gland is situated centrally immediately posterior to the cirrus

sac. The uterine coils pass posteriorly between the two testes and terminate immediately anterior to the excretory bladder. Anteriorly the uterine coils pass between the anterior testis and the posterior end of the cirrus sac. The metraterm is long, broad, slightly coiled posteriorly and has comparatively thin walls. It passes dorsally to the ventral sucker on the left side of the cirrus sac. The eggs are yellowish or dark-brown, operculated and measure 0·0285–0·0325 × 0·013–0·0165. The vitelline gland on the left side consists of follicles arranged continuously, while on the right side the follicles are arranged in definite groups. For the most part they lie exterior to the intestinal cæca, but some follicles are seen overlapping them. On the left side the gland extends from the anterior border of the ventral sucker to the posterior border of the hinder testis. On the right side it extends from the level of the middle of the cirrus sac to the end of the intestinal cæcum. In the specimen under study the extent of the vitelline gland therefore differs from that described by Mehra. The transverse vitelline duct on the right side is seen slightly posterior to the ovary and that on the left side passes some distance in front of the anterior testis.

Harshé (1932) described the new species, *Astiotrema gangeticus* obtained from the intestine of *Lissemys punctata* (Syn. *Emyda granosa*) at Allahabad. On a careful comparison of the description of this species with the specimen of *A. loossi* at the writer's disposal it is found that both the species are identical. The differences pointed out by Harshé as existing between *A. loossi* and his species are that in the latter there are spines on the ventral surface of the body, the receptaculum seminis is large, the vitelline follicles are continuous and not arranged in groups and the ovary is round. In the writer's specimen the ovary and the receptaculum seminis are similar to those of *A. gangeticus* and the vitellaria are arranged in groups on one side while on the other the follicles are continuous excepting for a short distance anteriorly. The arrangement of vitelline follicles in groups or otherwise is not therefore a point of specific importance in this case. The only valid difference between *A. loossi* and *A. gangeticus* is in the latter case of the presence of spines on the ventral surface of the body, but this in itself should not form a basis for the separation of one species from the other. It is therefore suggested here to regard *A. gangeticus* Harshé, 1932 as a synonym of *A. loossi* Mehra, 1931.

Astiotrema rami n.sp. (Fig. 5.)

About a dozen specimens of this species were obtained from the intestine of a *Lissemys punctata* at Nagpur in 1926.

The worms are elliptical with a rounded posterior extremity and a slightly attenuated anterior end. This latter has a tendency to bend ventrally during fixation. The entire body with the exception of the extreme posterior end is covered with backwardly directed scales. These are comparatively rare in the posterior fourth of the body. The parasites measure 1·96–3·67 in length and the maximum breadth which is attained at the level of, or slightly behind, the anterior testis is 0·6–1·1.

The mouth is situated subterminally at the anterior end and is surrounded by the oral sucker measuring 0·235–0·35 in diameter. The ventral sucker is smaller than the oral and measures 0·16–0·34 in diameter. On account of the peculiar curve of the anterior end of the worm the prepharynx could not be observed even in the sectionized specimens. The pharynx measuring 0·08–0·135 in diameter is globular and muscular. The œsophagus is short and measures 0·08–0·11 in length. The intestinal fork is situated some distance anterior to the ventral sucker. The intestinal cæca pass along the sides of the body and terminate at a distance of 0·28–0·43 from the posterior end of the body.

The excretory system consists of the excretory pore situated at the extreme posterior end leading into a Y-shaped bladder. The stem of the bladder is straight and bifurcates into two arms passing laterally in front of the anterior testis.

The male genitalia consist of two testes which lie obliquely and measure 0·32–0·54 × 0·285–0·46. The shape and nature of the testes is subject to much variation. In some specimens they appear more or less round with an entire margin while in others they are slightly lobed and have an irregular outline. In some cases their horizontal axis is longer while in others the longer axis is the antero-posterior one. The genital pore is situated between the ventral sucker and the intestinal fork. The cirrus sac is club-shaped and measures 0·375–0·47 × 0·12–0·18. It is seen to lie in some cases dorsal to the ventral sucker while in others it lies on the right side of that organ. It extends from the genital pore to an appreciable distance posterior to the ventral sucker. Its posterior border either touches or is level with the anterior border of the ovary. The vesicula seminalis is a simple, broad, elongated sac, filling about three-fourth

of the cirrus sac. The pars prostatica and the cirrus are very small as in other species of the genus.

The female genitalia consist of the ovary which is almost round and measures 0·17–0·33 × 0·225–0·32. It lies usually to the right of the middle line, but in one case it was found to lie almost in the centre of the body. The receptaculum seminis is more or less half moon-shaped and lies immediately behind the ovary. It measures 0·27 × 0·12. The shell gland lies in the centre of the body and is sometimes eclipsed by the receptaculum seminis. The Laurer's canal is present. The vitellaria are follicular and lie along the sides of the body. Their extent is subject to some variation. The gland on the left side is, as a rule, longer than that on the right side. On the left side it extends from the posterior border of the ventral sucker to the level of the posterior testis or some distance behind it. On the right side it extends from the anterior border of the ovary to the anterior border or the middle of the posterior testis. The uterine coils are very dense and occupy all the space behind the ovary excepting that occupied by the testes and the vitellaria. The metraterm lies on the dorsal surface of the ventral sucker, to the left of the cirrus sac. The eggs are elliptical, dark-brown, operculated and measure 0·04–0·0465 × 0·018–0·022.

The genus *Astiotrema* was proposed by Looss (1900) for the species *A. reniferum* and *A. impletum*. Stossich (1904) described the species *A. monticellii* from the intestine of *Tropidonotus viviparinus* in Naples. Odhner (1911) gave a description of the worms from the intestine of *Trionyx triunguis* and *Tretradon fahaka* calling them *A. reniferum* and *A. impletum* respectively. The writer is in agreement with Odhner in regard to the taxonomy of the worms from *Tetradon fahaka*, but he considers that the worms from *Trionyx triunguis* do not belong to the species *A. reniferum*. They differ from this species in the length of the intestinal cæca, in the testes being lobed and differently shaped instead of being entire and kidney-shaped, in the ovary being at the anterior third instead of near the middle of the body and in having the vitellaria extending at different levels. For these reasons the writer regards that the worms described by Odhner from *Trionyx triunguis* belong to a separate species for which the name *Astiotrema odhneri* n.sp. is proposed. Stossich (1904) had placed the species *Distomum erinaceum* Poirier, 1886 under the genus *Astiotrema*, but Odhner (1911) pointed out that it was

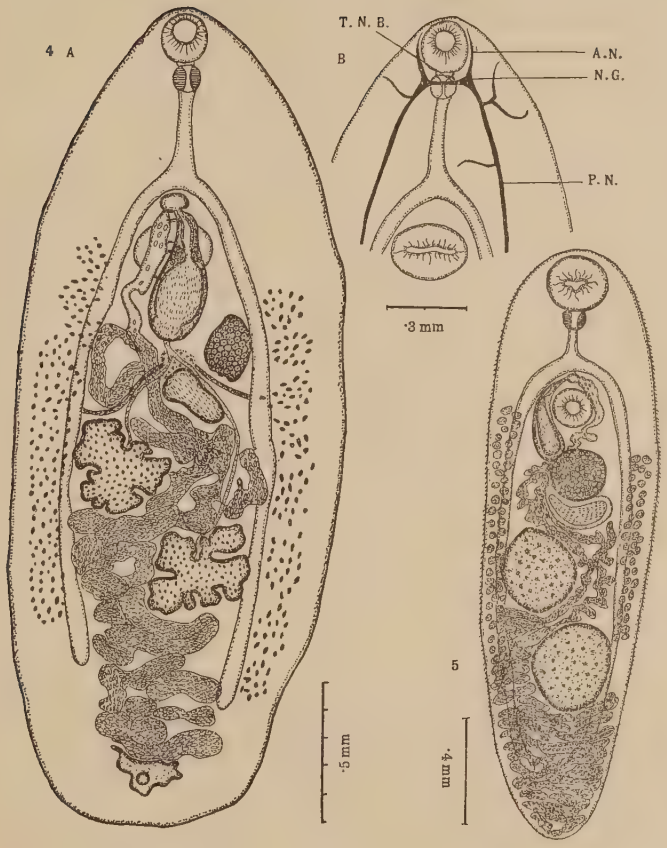

Fig. 4. *Astiotrema loossi*. A. Dorsal view of the entire worm. B. Diagram showing nervous system. A.N., Anterior nerve ; N.G., Nerve ganglion ; P.N., Posterior nerve ; T.N.B., Transverse nerve band.

Fig. 5. *Astiotrema rami* n.sp., dorsal view.

a monostomid form. In the recent years are recorded the species *A. loossi* Mehra, 1931, *A. elongatum* Mehra, 1931, *A. gangeticus* Harshé, 1932, *A. spinosa* Chatterji, 1933 and *A. indica* Thapar, 1933. Of these the species *A. gangeticus* has already been pointed out to be a synonym of *A. loossi* in an earlier part of this communication. Among the remaining species of *Astiotrema* the one described here resembles *A. reniferum* Looss, but it differs from it in the ovary being situated at about the anterior third of the body instead of near the mid-body, in the testes being round and irregular instead of kidney-shaped and in having a smaller and stouter cirrus sac. For these reasons it has been considered necessary to regard it a new species for which the name *Astiotrema rami* is proposed.

The specific diagnosis of *Astiotrema rami*.—Body elliptical. Length 1·96–3·63. Breadth 0·6–1·1. Oral sucker sub-terminal 0·235–0·35 dia. Ventral sucker 0·16–0·34 dia. Pharynx 0·06–0·135 dia. Œsophagus 0·08–0·11 long. Intestinal cæca terminate 0·28–0·43 from the posterior end. Excretory bladder Y-shaped. Testes globular or irregular, 0·32–0·54 × 0·285–0·46. Cirrus sac 0·375–0·47 × 0·12–0·18, stout, protruding behind ventral sucker and situated dorsally to it. Ovary at about anterior third of body, almost round, to the right, 0·17–0·33 × 0·225–0·32. Receptaculum seminis half moon-shaped, 0·27 × 0·12. Laurer's canal present. Vitellaria extend on the right side from the ovary to the anterior testis and on the left from the ventral sucker to the posterior testis or some distance behind it. Ova 0·04–0·0465 × 0·018–0·022.

Host.—*Lissemys punctata.*

Location.—Intestine.

Locality.—Nagpur, C.P., India.

The type slide deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar.

With a view to facilitate a ready identification of the existing species of *Astiotrema* the following key has been constructed.

Key to the species of *Astiotrema*.

1.	Oral sucker equal to ventral sucker	*A. indica*
	Oral sucker smaller than ventral sucker	7
	Oral sucker larger than ventral sucker	2
2.	Intestinal fork posterior to ventral sucker	*A. monticellii*
	Intestinal fork anterior to ventral sucker	3
3.	Vitellaria not extending posterior to anterior testis ...	*A. impletum*
	Vitellaria extending posterior to anterior testis	4
4.	Intestinal cæca not passing behind posterior testis ...	*A. odhneri*
	Intestinal cæca passing behind posterior testis	5

5.	Vitellaria extending anterior to ventral sucker	*A. elongatum*
	Vitellaria not extending anterior to ventral sucker ...	6
6.	Ovary nearer the midbody, testes kidney-shaped ...	*A. reniferum*
	Ovary nearer the ventral sucker, testes rounded or irregular	*A. rami*
7.	Testes deeply lobed	*A. loossi*
	Testes round	*A. spinosa*

Acknowledgments.

The material dealt with in this communication from the animals which died in the Zoological Gardens, Calcutta, was collected by Dr. P. A. Maplestone, D.S.O. and transferred to Dr. V. T. Korké of the Central Research Institute, Kasauli. The writer takes this opportunity of expressing his indebtedness to Dr. P. A. Maplestone, Dr. V. T. Korké and the Director, Central Research Institute, Kasauli, for so generously placing the material at his disposal.

The entire work published in this communication was done under the supervision of Professor R. T. Leiper, F.R.S. to whom the writer wishes to express his gratitude.

Summary.

The formation of the family Ommatobrephidæ for *Ommatobrephus* Nicoll has been accepted.

With the help of the material from *Zamenis mucosus* the species *O. folium* Thapar & Ali has been shown to be a synonym of *O. lobatum* Mehra. The descriptions of this species given by Mehra and Thapar & Ali have been critically reviewed. Measurements of the material of *O. lobatum* at the writer's disposal have been given.

Acanthostomum burminis (Bhalerao) from *Tropidonotus piscator* in Nagpur has been recorded.

The synonymy of Lepodermatidæ Odhner with Plagiorchidæ Lühe has been discussed and the latter name has been accepted in preference to the former.

The family status of Cephalogonimidæ has not been agreed upon, but Cephalogoniminæ as a subfamily of Plagiorchidæ has been accepted.

Variations occurring in *Cephalogonimus amphiumæ* obtained from *Lissemys punctata* in Nagpur have been noted and the species *C. gangeticus* Pande and *C. magnus* Sinha have been shown to be its synonyms. A review of the various species of *Cephalogonimus* recorded up to the present moment has been made. Measurements of the writer's specimens of *C. amphiumæ* have been given.

The new species, *Styphlodora nicolli*, from the intestine of *Zamenis mucosus* has been described and separated from the allied species of the genus. A key to the existing species of *Styphlodora* has been given.

Encyclometra colubrimurorum (Rud.) has been recorded from *Zamenis mucosus* in Calcutta.

Tremiorchis ranarum Mehra & Negi has been recorded from *Rana tigrina* in Karnal. The synonymy of *Centrovitus pentadelphi* Bhalerao with the former species has been pointed out.

An adult specimen of *Astiotrema loossi* Mehra obtained from *Lissemys punctata* has been described and many differences existing between it and the immature specimen described by Mehra have been pointed out. The species *A. gangeticus* has been shown to be a synonym of *A. loossi*.

The new species, *Astiotrema rami*, has been described and separated from the allied species. A review of the existing species of *Astiotrema* has been made and a key to them has been given. *A. odhneri* n.sp. is proposed to replace *A. reniferum* of Odhner, 1911.

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Journal of Helminthology, Vol. XIV, *No.* 4, *December*, 1936, *pp.* 207–228.

Studies on the Helminths of India. Trematoda III.

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Lecithodendriidæ Odhner, 1910.

Pleurogenetinæ Looss, 1899.

Pleurogenes Looss, 1896.

Pleurogenes gastroporus Lühe, 1901.

This species was first described by Lühe in 1901 from the intestine of the frog, *Rana cyanophlyctis*, in India. Mehra & Negi in 1928 described a new variety of this species, *Pleurogenes gastroporus* var. *equalis*, from the intestine of *Rana tigrina* in Allahabad and Benares. The joint authors differentiate their variety from the species in the following respects :— (1) More posterior position of the excretory pore. (2) Receptaculum seminis and shell gland lying in front of and not dorsal to ventral sucker. (3) Equal size of suckers. (4) Smaller size of ovary and testes. (5) Size of suckers. (6) Cirrus sac not so curved. (7) Host being different species of *Rana*. The writer had obtained in 1928 a few specimens from a *Rana tigrina* at Nagpur, which are referable to the species *Pleurogenes gastroporus* Lühe, 1901. With the help of this material it is proposed to offer a few remarks on some points of difference that have been stated to exist between the species of Lühe and the variety of the joint authors. Only two specimens have been studied : one of them in an entire mount and the other in serial sections. The material at the disposal of the writer is smaller and measures 0·68–0·69 mm. in length and 0·43–0·49 mm. in breadth. In regard to the position of the excretory pore, it lies, as the joint authors have stated, slightly in front of the posterior end and not as far from it as has been indicated in Lühe's Fig. 1. There appears to be undoubtedly some mistake in the Fig. 1 published by Lühe in this respect. In regard to the position of the receptaculum seminis and the shell gland it is found that these organs lie, as the joint authors have stated, in front of the ventral sucker, slightly to the right side and not dorsal

to the ventral sucker. In regard to the relative size of the suckers the joint authors state that they are equal, while Lühe describes the ventral sucker to be larger. If, however, the three figures published by Lühe are carefully examined it is found that in the figure nos. 3 and 4 the ventral sucker is no doubt larger than the oral, but in the fig. no. 2 the oral sucker is distinctly larger than the ventral one. In one of the specimens studied by the writer the oral sucker is larger, while in the other it is smaller than the ventral sucker. It appears therefore that this feature has no significance in this particular species. The remaining four points of difference have been considered by the joint authors to be of minor importance and on this account deserve no consideration here.

The writer does not approve of the tendency to form new subspecies. In cases where differences observed do not justify the creation of a new species it is advisable to record these variations occurring in the original species itself instead of proposing a new variety name.

Ganeo Klein, 1905.

Ganeo korkei n.sp. (Fig. 1.)

The writer had obtained about two dozen specimens of the genus *Ganeo* from the frog, *Rana tigrina*, at Nagpur in 1928. Of these, eight flukes were studied in *toto* mounts. All these, with the exception of one, turned out on examination to be *Ganeo tigrinum* Mehra & Negi, 1928. It is proposed to give here a description of the one interesting form discovered.

The worm is elliptical in form with the anterior part sharply attenuated and a bluntly rounded posterior end. It measures 2·17 mm. in length and the maximum breadth, which is attained immediately behind the genital opening, is 0·63 mm. The entire body is covered with spines. The genital pore is situated on the left border at about one-sixth the body length from the anterior end.

The mouth is situated at the extreme anterior end and is surrounded by the oral sucker measuring 0·105 × 0·09 mm. The ventral sucker is situated at about the anterior two-sevenths of the body and measures 0·135 mm. in diameter. The oral sucker is followed by the prepharynx measuring 0·05 mm. in length. The pharynx is a globular, muscular body measuring 0·07–0·065 mm. The œsophagus is long and slender and measures 0·28 mm. in length. The intestinal fork is situated at a distance

of 0·48 mm. from the anterior end. The intestinal cæca pass along the sides of the body and terminate at a distance of 0·48 mm. from the posterior end.

The excretory system consists of the excretory pore situated at a small distance from the posterior end leading into the excretory bladder which is more or less V-shaped ; a small stem being present. Anteriorly the cornua of the bladder extend almost up to the level of the posterior border of the ventral sucker.

The male genitalia consist of two entire testes lying obliquely one behind the other, some distance behind the intestinal fork. The anterior testis is barrel-shaped and measures 0·13 × 0·08 mm., while the posterior one is somewhat oval and measures 0·13 × 0·125 mm. Both the testes are situated in the intra-cæcal area. The vesicula seminalis is seen lying on the left side of the posterior testis and is very different in structure from that described for other species of the genus. It consists of a more or less oval sac lying on the dorsal side. It opens into a smaller rounded sac situated ventrally. From this latter a fairly stout duct, bent in the form of U passes obliquely forwards and opens into the voluminous pars prostatica measuring 0·26 × 0·085 mm. The pars prostatica is surrounded by a very large number of unicellular prostatic glands as in the other species. The cirrus is 0·145 mm. long and opens into the genital atrium situated near the margin of the body on the left side.

The ovary is almost round and is situated on the right side, immediately behind the posterior testis. It is larger than both the testes and measures 0·173 × 0·165 mm. A small oviduct is seen emerging internally from about a third of its length from the anterior border. The receptaculum seminis is a pear-shaped organ lying obliquely, immediately posterior to the ovary. It measures 0·135 × 0·073 mm. The shell gland lies centrally at the same level as the ovary. The uterus passes posteriorly to a distance slightly in front of the posterior end. It then takes an anterior course. Some of the coils are seen overlapping the intestinal cæca. Ultimately the uterus is seen passing on the left side of the vesicula seminalis and dorsal to the pars prostatica and the cirrus. Metraterm measuring 0·135 mm. in length is clearly distinguishable. The vitellaria are situated almost in the centre of the body and extend posteriorly from the middle of the posterior testis on the right side and

from the level of the anterior border of the testis on the left side. The gland on the right side is therefore larger than that on the left. The follicles are arranged in five groups on the left side and in seven groups on the right. The ripe ova in the metraterm measure 0·0245–0·025 × 0·012–0·0125 mm.

The genus *Ganeo* was proposed by Klein (1905) for the species *G. glottoides* obtained from the intestine of *Rana hexadactyla*. Subsequently to this date only three more species were described : *G. tigrinum* Mehra & Negi, 1928 from the intestine and rectum of *Rana tigrina* in Allahabad, *G. gastricus* and *G. attenuatum* Srivastava, 1933 from the stomach and intestine respectively of *Rana cyanophlyctis* in Sitapur, Oudh, India. A comparison of the specimen described here with the species recorded up to the present time reveals that it has closer affinities with the species *G. attenuatum* Srivastava, 1933. It can, however, be separated from it in the following respects : (1) The oral sucker being terminal. (2) The ovary being larger than the testes. (3) The shell gland being lateral to ovary. (4) The vesicula seminalis having a different structure. (5) The vitellaria extending on the right side as far as the middle of the posterior testis and on the left as far as the anterior border of the ovary. These points being of sufficient importance to justify the creation of a new species it has been decided to regard the species described here as a new one for which the name *Ganeo korkei* has been proposed in honour of Dr. V. T. Korké.

The specific diagnosis of *Ganeo korkei* n.sp. : Body elliptical, attenuated sharply at the anterior end. Length 2·17 mm. Maximum breadth 0·63 mm. Cuticle covered with spines. Oral sucker terminal, 0·105 × 0·09 mm. Ventral sucker 0·135 mm. dia. Genital pore lateral, at one-sixth of body length from anterior end. Prepharynx 0·05 mm. long. Œsophagus 0·28 mm. long. Intestinal cæca terminating 0·48 mm. from posterior end. Excretory pore subterminal, excretory bladder V-shaped. Anterior testis barrel-shaped, 0·13 × 0·08 mm. Posterior testis somewhat oval, 0·13 × 0·125 mm. Vesicula seminalis consists of a large oval and a small round sac and a short U-shaped duct. Pars prostatica 0·26 × 0·085 mm. Cirrus 0·145 mm. long. Ovary larger than testes 0·173 × 0·165 mm. Receptaculum seminis pear-shaped, 0·135 × 0·073 mm. Shell gland internal to ovary. Uterine coils reaching posteriorly to a small distance from posterior end. Metraterm 0·135 mm. long. Vitellaria extending

anteriorly on the right as far as the middle of the posterior testis and on the left as far as the level of the anterior border of the ovary. Eggs measuring 0·0245–0·025 × 0·012–0·0125 mm.

Host.—*Rana tigrina.*

Location.—Intestine.

Locality.—Nagpur.

Type specimen deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar-Kumaun, U.P., India.

Ganeo tigrinum Mehra & Negi, 1928.

A large number of specimens were obtained in 1929 from the intestine of the frog, *Rana tigrina*, in Nagpur. These on examination proved to be *Ganeo tigrinum* Mehra & Negi, 1928. Since the joint authors (1928) have given a very detailed account of this parasite further remarks on it are not necessary.

MEHRAORCHIS Srivastava, 1934

Mehraorchis ranarum Srivastava, 1934. (Figs. 2-3).

A large number of specimens were collected by the writer in 1929 from the bile-ducts and gall-bladder of the frog, *Rana tigrina*, at Nagpur, which are referable to the species *Mehraorchis ranarum* described by Srivastava (1934) from the body cavity of *Rana cyanophlyctis* in Sitapur. It appears that the encysted metacercaria of this species after being liberated from the cysts in the stomach of the frog pass to the duodenum wherefrom they ascend the bile-ducts to reach finally the gall-bladder. An alternative course of migration taken by the metacercaria appears to be through the intestinal wall into the body cavity where also they develop into the adults. A careful comparison of the material at the disposal of the writer with that described by Srivastava reveals that the former differs from the latter in some minor details. It is therefore proposed to record here some variations occurring in this species and to give later some measurements of the material at the writer's disposal.

In the specimens described by Srivastava the oral sucker has been stated to be subterminal and so also is the mouth. In none of the specimens at the writer's disposal was the oral sucker subterminal. The mouth as well as the oral sucker was terminal in all cases.

In the specimens from frogs in Sitapur the prepharynx has been stated

to be absent, but in the specimens with the writer a distinct prepharynx is present. It may, however, be remarked here that in some contracted specimens it is rather difficult to see this structure.

In Srivastava's specimens the pharynx has been stated to be conical, but in all the writer's specimens it is a globular, muscular structure.

In Sitapur specimens the intestinal bifurcation has been stated to be present at one-fourth the body length from the anterior end. In the specimens from Nagpur its position varies from one-fourth to one-third the body length from the anterior end.

As remarked by Srivastava the testes are variable in shape. They may be round, oval or irregular.

The shape of the ovary is also subject to variation. In a large majority of specimens it is oval but in a few it is lobed. It was never found with a crenated margin as in the Sitapur specimens.

The receptaculum seminis is elongated and bulb-shaped as described by Srivastava in the large specimens, but in all the smaller ones it is round. Its connection with the Laurer's canal and the oviduct has been shown in the accompanying figure no. 2.

The uterus is densely coiled in large and gravid individuals as figured by Srivastava, but in the smaller forms it is much less coiled as shown in the figure no. 3.

In younger forms the excretory bladder was very clearly visible and its form is as indicated in figure no. 3.

Measurements.—Length 1·95–3·93 mm. Breadth 1–2·82 mm. Oral sucker 0·27–0·51 mm. dia. Prepharynx 0·08 mm. long. Pharynx 0·175 × 0·185 mm. Œsophagus 0·2–0·345 mm. long. Ventral sucker 0·165 mm. dia. Intestinal cæca terminate 0·123–0·235 mm. from posterior end. Testes 0·165 × 0·12, 0·46 × 0·485 mm. Cirrus sac 0·57 × 0·17–0·93 × 0·23. Ovary 0·165 × 0·135–0·52 × 0·335 mm. Eggs 0·03–0·035 × 0·013–0·017 mm.

LECITHODENDRIINÆ Looss, 1896.

PROSTHODENDRIUM Dollfus, 1931.

Prosthodendrium pushpai n.sp. (Fig. 5).

The parasite proposed to describe here was obtained in 1925 from the intestine of *Nyctinomus plicatus* in Rangoon. The writer had on previous occasion (Bhalerao, 1926) described a number of trematodes from

this interesting house bat in Rangoon. Subsequently to the writer's publication Northup (1928) added considerably to our knowledge of the parasites of this host. It will be apparent from the number of parasites recorded from this animal that it is very rich in its parasitic fauna and it is considered that the diet of the animal which consists of varied insects is responsible for such a large number and variety of parasites which it harbours.

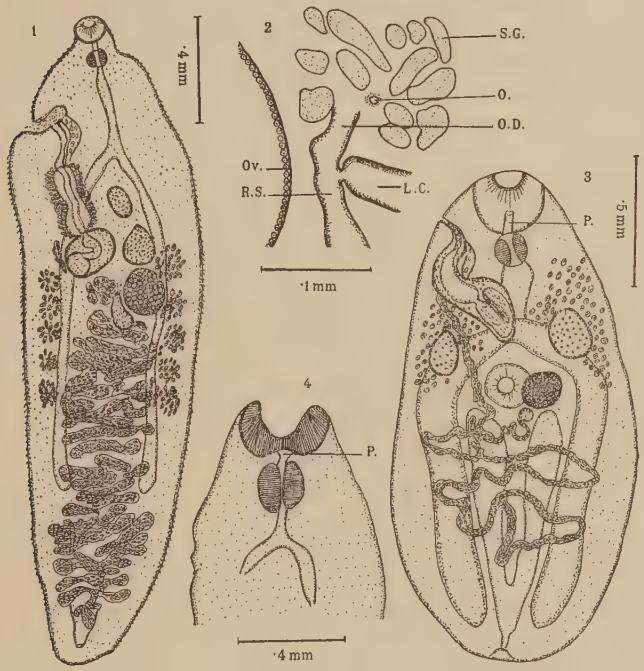

Fig. 1. *Ganeo korkei* n.sp., dorsal view :

Fig. 2. *Mehraorchis ranarum*, section showing the relation of the Laurer's canal, the receptaculum seminis and their connection with the oviduct : L.C., Laurer's canal; O., Ootype; OV., Wall of the ovary : O.D., Oviduct; R.S., Receptaculum seminis; S.G., Shell gland.

Fig. 3. *Mehraorchis ranarum*, dorsal view of sexually mature but comparatively younger form : P., Prepharynx.

Fig. 4. *Opisthorchis noverca*, section passing through the anterior part of the worm showing the various components of the alimentary canal : P., Prepharynx.

The worm is pyriform in shape. The cuticle is smooth and is completely devoid of any armature. It measures 1·07 mm. in length and the maximum breadth which is attained at about the midbody is 0·97 mm. The mouth is situated at the anterior end and is surrounded by the oral sucker measuring 0·175 mm. in diameter. The ventral sucker is situated almost in the midbody and is slightly smaller than the oral sucker. It measures 0·16 mm. in diameter. Immediately behind the oral sucker is seen the pharynx measuring 0·075 laterally. Its anterior portion is partially overlapped by the oral sucker. The œsophagus was not seen. The intestinal cæca diverge laterally from the posterior border of the pharynx and terminate anteriorly to the testes. They lie almost touching the latter organs. The excretory pore is situated at the extreme posterior end. It leads into a V-shaped bladder the arms of which pass anteriorly as far as the posterior border of the testes.

The testes are two round or almost round bodies situated immediately behind the intestinal cæca. Their zone is anterior to that of the ventral sucker. They measure 0·24–0·265 × 0·2–0·24 mm. The genital pore is situated centrally between the ventral sucker and the intestinal fork. Its zone corresponds with that of the testes. The vesicula seminalis is a thick coiled duct. The pars prostatica occupy a large area in the testicular zone. The genital atrium is devoid of any armature.

The ovary is situated to the right of the genital pore, in the zone corresponding with that of the testes. It is an almost round body measuring 0·125 mm. in diameter. It is partially overlapped by the right testis. The vitellaria consist of numerous follicles lying dorsally on each side of the anterior portion of the body. They extend from the middle of the oral sucker to about the middle of the testes. The vitelline ducts unite together near the antero-lateral border of the ventral sucker. The shell gland is also situated antero-laterally to the ventral sucker. The uterus occupies almost the entire area of the body posterior to the level of the testes. The uterine coils are seen to fill first the left side of the body and then the right. The eggs are brown and measure 0·025–0·028 × 0·012–0·015 mm.

The genus *Lecithodendrium* was proposed by Looss in 1896. Later in 1899 he emended the definition of this genus and got it bound by the type-species *ascidia*. In regard to this species recently Dollfus (1931) has pointed out that there exists a real *ascidia* species of van Beneden

with vitellaria anterior to testes and a false *ascidia* species of von Linstow, Looss, Lühe, etc., with vitellaria posterior to testes. Dollfus (1931) suggested the name *linstowi* for the false *ascidia* which is the type of *Lecithodendrium* while the true *ascidia* was placed by him in his new genus *Prosthodendrium* with its type *dinanatum* Bhalerao, 1926. In the genus *Prosthodendrium* are therefore included the species having vitellaria anterior to testes. In a passion to apply the article 35 of the Rules of International Nomenclature Brandes (1888) and Stiles & Nolan (1931) suggested the names *lagena* and *lagincula* respectively to replace *ascidia* van Beneden, but Dollfus (1931) pointed out that this procedure was not necessary in the case of the " Pseudogenus *Distoma* " which does not constitute a definite systematic unit.

In the same paper Dollfus points out that the genus *Mesodendrium* Faust, 1919, having vitellaria posterior to testes falls into synonymy of *Lecithodendrium* as amended by Looss, 1899. The writer also is in complete agreement with this view.

In the genus *Acanthatrium* Faust, 1919 also the vitellaria are anterior to testes. The only feature by which it is differentiated from *Prosthodendrium* is the possession of spines on the genital atrium : the other characters claimed for it being of a very variable nature. The writer (Bhalerao, 1926) discovered in Burma the species *P. orospinosa* which possesses spines on the oral sucker. It is therefore evident from this that the occurrence of spines on some organ or the other within the genus *Prosthodendrium* is not a very uncommon phenomenon, and for this reason the writer suggests that the genus *Acanthatrium* be also merged into the synonymy of the genus *Prosthodendrium*.

In recently published papers Mehra (1935) and Pande (1935) retain the genus *Lecithodendrium* for the forms having vitellaria anterior to testes and the genus *Mesodendrium* for those having vitellaria posterior to them, but it may be seen from the previous remarks that the writer does not approve of this procedure.

In the light of what has been said previously it is found that the valid species which fall within the purview of the genus *Lecithodendrium* are : *L. linstowi* Dollfus, 1931, *L. granulosum* (Looss, 1907), *L. hirsutum* (Looss, 1896), *L. attia* (Bhalerao, 1926), *L. macrostomum* (Ozaki, 1929), *L. spathulatum* (Ozaki, 1929), *L. breckenridgei* Macy, 1936. These seven species

can be differentiated from each other with the help of the key published by Macy (1936).

The valid species that were previously referred either to the genus *Lecithodendrium* or *Acanthatrium* and now forming legitimately the members of the genus *Prosthodendrium* Dollfus, 1931 are :— *P. sphærula* (Looss, 1896), *P. ovimagnosum* (Bhalerao, 1926), *P. glandulosum* (Looss, 1896), *P. obtusum* (Looss, 1896), *P. eptesici* (Alicata, 1932), *P. nycteridis* (Faust, 1919), *P. dinanatum* (Bhalerao, 1926), *P. pyramidum* (Looss, 1896), *P. cordiforme* (Braun, 1900), *P. liliputanum* (Travassos, 1928), *P. chilostomum* (Mehlis, 1831), *P. orospinosa* (Bhalerao, 1926), *P. longiforme* (Bhalerao, 1926), *P. chefrenianum* (Looss, 1896), *P. posticum* (Stafford, 1905), *P. urna* (Looss, 1907), *P. luzonicum* (Tubangui, 1928), *P. loossi* (Pande, 1935), *P. mehrai* (Pande, 1935), *P. bhaleraoi* (Pande, 1935) and *P. ascidia* (van Beneden, 1873). Among these eighteen species of *Prosthodendrium* the one described here, on account of its ovary being in the same level as the testes, oral sucker being without spines, and vitellaria extending posterior to the intestinal cæca, is closely related to the species *P. urna*, but it can be differentiated from this species by the extent of the vitellaria, by the testes being level with the genital pore instead of being postero-lateral to the ventral sucker, by the absence of prepharynx and œsophagus and by the different disposition of the uterine coils. For these reasons it has been proposed to regard it a new species for which the name *Prosthodendrium pushpai* is proposed.

Specific diagnosis of *Prosthodendrium pushpai* :—Body pyriform. Length 1·07 mm. Breadth 0·97 mm. Cuticle unarmed. Oral sucker terminal, without spines, 0·175 dia. Ventral sucker in the midbody, 0·16 mm. dia. Prepharynx and œsophagus apparently not visible. Pharynx 0·075 mm. laterally. Intestinal cæca passing laterally and terminating immediately anterior to testes. Excretory bladder V-shaped. Genital pore midway between intestinal cæca and ventral sucker. Testes almost round, level with genital pore. Ovary smaller than testes, in the same level as the latter. Vitellaria extending dorsally from the level of oral sucker to the middle of testes, not meeting centrally, follicles numerous. Uterine coils posterior to testes, first filling up one side, then the other. Eggs brown, 0·025-0·028×0·012-0·015 mm.

Host.—*Nyctinomus plicatus.*

Location.—Intestine.
Locality.—Burma (Rangoon).

Type slide deposited in the Helminthological Collection of the Imperial Institute of Veterinary Research, Muktesar-Kumaun, U.P., India.

With a view to facilitate a ready identification of the numerous species of *Prosthodendrium* the following key has been tentatively constructed.

Key to the species of *Prosthodendrium*.

1.	Ovary lobed	2
	Ovary entire	5
2.	Genital atrium with spines	*P. sphærula*
	Genital atrium without spines	3
3.	Ovary extending almost from one testis to the other ...	*P. ovimagnosum*
	Ovary confined between the right testis and the pseudocirrus sac	4
4.	Genital pore anterior to the level of testes	*P. glandulosum*
	Genital pore level with testes	*P. obtusum*
5.	Ovary posterior to testes	6
	Ovary anterior to or level with testes	11
6.	Genital atrium with spines	7
	Genital atrium without spines	8
7.	Testes level with ventral sucker	*P. eptesici*
	Testes anterior to ventral sucker	*P. nycteridis*
8.	Oral sucker larger than ventral sucker	9
	Oral sucker smaller than ventral sucker	10
9.	Pseudocirrus sac and ovary partially overlapping ventral sucker	*P. dinanatum*
	Pseudocirrus sac lateral to ventral sucker and ovary removed from the latter	*P. loossi*
10.	Genital pore level with testes	*P. pyramidum*
	Genital pore anterior to level of testes	*P. cordiforme*
11.	Oral sucker with spines	*P. orospinosa*
	Oral sucker without spines	12
12.	Vitellaria not extending posterior to intestinal cæca ...	13
	Vitellaria extending posterior to intestinal cæca ...	16
13.	Ovary anterior to testes	14
	Ovary level with testes	15
14.	Genital pore anterior to the level of ovary	*P. longiforme*
	Genital pore posterior to the level of ovary	*P. bhaleraoi*
15.	Oral sucker one and half times larger than ventral sucker	*P. chefrenianum*
	Oral sucker three to four times larger than ventral sucker	*P. mehrai*
	Oral sucker and ventral suckers of equal diameter ...	*P. posticum*
16.	Vitellaria meeting centrally	17
	Vitellaria not meeting centrally	18

17.	Body elongate, oral sucker much larger than ventral sucker	*P. luzonicum*
	Body round, oral sucker slightly larger than ventral sucker	*P. ascidia*
18.	Testes level with genital pore	*P. pushpai*
	Testes postero-lateral to ventral sucker	*P. urna*

Note.—The species *P. chilostomum* not being adequately known has not been included in the above key.

Prosthodendrium cordiforme (Braun, 1900).

A few parasites which are referable typically to *Prosthodendrium cordiforme* (Braun, 1900) obtained from the intestine of *Nyctinomus plicatus* in Rangoon were available for study. These agree in every respect with those described by Braun (1900).

Prosthodendrium ovimagnosum (Bhalerao, 1926).

The writer is indebted to Mr. Abdus Salam for the material of this species which he had obtained from the bat, *Nycticejus pallidus*, in the Punjab. These specimens were found to agree in all respects with those that the writer had described in 1926 from the intestine of *Nyctinomus plicatus* in Rangoon. It appears that *P. ovimagnosum* enjoys a fairly wide distribution, for it has also been recorded from the intestine of *Scutophilus emmanckii* in the Philippine Islands by Tubangui (1928).

OPISTHORCHIDÆ Lühe, 1901.

OPISTHORCHIS R. Blanchard, 1895.

Opisthorchis noverca Braun, 1902. (Fig. 4).

Complete synonymy and the history of the discovery of this parasite has recently been given by Erhardt (1935). This parasite was on previous occasions recorded from the dog and man. The writer (Bhalerao, 1931) had recorded its occurrence in pigs in Calcutta. The writer has on the present occasion two consignments of this parasite for examination. One of them is from a dog in the Punjab and the other being from the intestine of the wild dog, *Cyon dukhunensis*, collected in Calcutta by Dr. P. A. Maplestone in 1929.

The specimens from the dog in the Punjab conform in every respect to the description of this parasite given by previous authors, but the material collected from the wild dog in Calcutta is somewhat different from the typical *Opisthorchis noverca* and corresponds with that from pigs, which the writer had recorded in 1931. Curiously enough both

the specimens have been collected from the same locality, *viz.*, Calcutta. It was already remarked in 1931 by the writer that considerable difficulty was experienced in discovering the cuticular spines in the case of the specimens from pigs. In the specimens from the wild dog the spines are not at all visible. Even in a sectionized specimen these

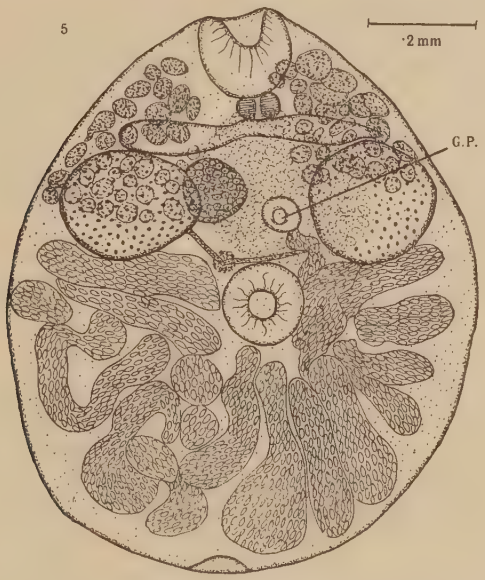

Fig. 5. *Prosthodendrium pushpai* n.sp., ventral view : G.P., Genital pore.

cuticular structures were not noticeable. It appears that there is a tendency in this species to lose the cuticular spines or it may also be possible that there exists a distinct variety without the presence of the cuticular spines.

Another feature of this species which the writer has discovered is the presence of a prepharynx. None of the previous workers has noticed this structure, although the writer has reasons to presume that it is present in every case. It is quite certain that unless special efforts are made to see this structure in entire mounts of the parasite it easily escapes the notice of an observer. It can, however, be noticed

with considerable ease in a sectionized specimen. The accompanying sketch of a section indicates this structure quite distinctly.

The specimens from the wild dog measure 4·8–5·6 mm. in length and 1·85–2·1 mm. in breadth.

ECHINOSTOMATIDÆ (Looss, 1902) Dietz, 1909

ECHINOCHASMUS Dietz, 1909.

Echinochasmus perfoliatus (Ratz, 1908), Dietz, 1909.

Numerous specimens of this species obtained from cats in Calcutta by Dr. S. A. Gunavardhana and by Mr. Abdus Salam in Muktesar were available for study. These agree in every respect with the description of *E. perfoliatus* given by the previous authors. The writer has nothing new to add to the organisation of this parasite.

SCHISTOSOMATIDÆ (Looss, 1899) Poche, 1909.

SCHISTOSOMA Weinland, 1858.

Schistosoma spindalis Montgomery, 1906.

Through the courtesy of Dr. Kalappah of the Civil Veterinary Department, Coorg, an opportunity was afforded to examine these worms collected from the portal veins of a calf in Somawarpeth, Coorg. Only one female and eight males were available for study. These agreed in every respect with the non-tuberculate variety of *Schistosoma spindalis* described by the writer in 1932.

The males measure 7·1–12·5 mm. in length. The cuticle is completely devoid of any tubercles. The number of the testes vary from three to eight.

The female is 12·5 mm. long. The ova measure 0·198–0·22 × 0·023–0·24.

HEMIURIDÆ Lühe, 1901.

DEROGENETINÆ Odhner, 1927.

HALIPEGUS Looss, 1899.

The writer follows Odhner (1927) and Fuhrmann (1928) in assigning *Halipegus* to the subfamily Derogenetinæ of the family Hemiuridæ on account of the close similarity between the genera *Halipegus* and *Derogenes*. He is not in favour of creating an independent family Halipegidæ for the only genus *Halipegus* as Poche had done in 1925.

Halipegus mehransis Srivastava, 1933.

Only one specimen obtained from the frog, *Rana tigrina*, in Nagpur was available for study. This specimen is referable, in some respects, to *Halipegus mehransis* var. *minutum* Srivastava, 1933, but it does not correspond in all respects to the variety *minutum* described by Srivastava (1933). In respect of the size of the body it resembles the species *mehransis* rather than the variety *minutum*. The filament of the egg is, however, smaller than that of either the species or the variety. The relative sizes of the suckers and the transversely oval disposition of the oral sucker resemble these structures in the var. *minutum*. In view of these differences observed the writer proposes to abolish the variety *minutum* of Srivastava.

The specimen from Nagpur is 4·7 mm. long and its maximum breadth is 1·15 mm. The ventral sucker is twice as large as the oral. The eggs measure 0·043–0·045 × 0·021–0·023 mm. The filament is 0·088–0·104 mm. long.

Halipegus sp.

Two specimens, somewhat indifferently preserved, obtained from the intestine of a *Rana tigrina* in Nagpur, were available for study. Although one of the specimens was studied in an entire mount and the other in serial sections sufficient details could not be gathered in order to ascertain a correct specific identity. It, however, closely resembles the species *H. longispina* Klein, 1905, and future investigations might even reveal that it is identical to it.

Heterophyidæ Odhner, 1914.
Haplorchinæ (Looss, 1899) Poche, 1926.

Haplorchis Looss, 1899.

The genus *Haplorchis* and *Galactosomum* were included by Looss (1899) in the subfamily Haplorchinæ. Witenberg (1929) removed the genus *Galactosomum* from this subfamily and transferred it to Heterophyinæ. Looss included in the genus *Haplorchis* the only two species, *H. pumilio* (Looss, 1896) and *H. cahirinus* (Looss, 1896). Nishigori (1924) created the subfamily for the reception of his new genus *Monorchotrema* in which were included the two new species : *M. taihokui* and *M. taichui*. Faust and Nishigori in 1925 worked out the life-cycle of these

two species of Nishigori. Witenberg (1929) remarked that it is highly probable, after the revision of the type-specimens of *Haplorchis* and *Monorchotrema*, that these genera will be found to be identical. The year following, Witenberg (1930) remarked that the type-species, *Monorchotrema taihokui* Nishigori, 1924, was undoubtedly a synonym of *Haplorchis pumilio* (Looss, 1896). He further remarked that the generic name *Monorchotrema* Nishigori, 1924, falls into the synonymy of *Haplorchis* Looss, 1899, and thus the second species of this genus should be called *Haplorchis taichui* (Nishigori, 1924). He also suggested that the species *H. cahirinus* (Looss, 1896) must be excluded from the genus *Haplorchis* because of its long prepharynx and advanced position of testes. Witenberg even suggests the exclusion of this species from the family Heterophyidæ since it is parasitic in a piscian host, but in recent years heterophyid trematodes have been recorded from fishes also. In this connection the works of Manter (1934), Tubangui (1933) and Mueller & Van Cleave (1932) may be quoted.

Katsuta (1932) described the two species *Monorchotrema yokogawai* & *M. microrchia* from dogs and cats in Formosa. Although he considers that *Monorchotrema* is identical with *Haplorchis* he regards the former name to be valid, since it is a better defined genus. Chen (1936), however, is against this procedure, as according to him the description of *H. pumilio* is very careful and is quite adequate for the diagnosis of the genus. He further regards that *H. microrchia* is a synonym of *H. taichui*.

Tubangui (1933) added the species *H. anguillarum*, but since this species has two testes it should be excluded from the genus *Haplorchis*. The same year Fernando (1933) described the species *H. pearsoni* from the rectum of the Brown Fish Owl, *Katapa ceylonensis ceylonensis*, in Colombo, but the description of this species is not complete particularly in respect of the gonotyle and its armature.

Gohar (1934) described *H. milvi* from the Egyptian Kite and considered that *Haplorchis* and *Monorchotrema* were two distinct genera on the ground of the relative position of the testis and the ovary. Chen (1936) has, however, pointed out that this character is very variable and can not be utilized in separating one genus from the other.

According to Chen (1936) there are only three valid species of *Haplorchis*:

H. pumilio, *H. taichui*, and *H. yokogawai*. The validity of *H. milvi* is questioned by him. He apparently was unaware of *H. pearsoni*, which has not been adequately described in order to enable one to judge its validity.

Haplorchis taichui (Nishigori, 1924).

Through the courtesy of Dr. S. A. Gunavardhana and Mr. Abdus Salam an opportunity was afforded to examine the worms collected from cats in Calcutta and Muktesar respectively. Coincidently on both the occasions the flukes were mixed with *Echinochasmus perfoliatus*. The worms on examination proved to be *Haplorchis taichui* (Nishigori, 1924). They agree in every respect with the description of this species given by the previous authors and for this reason no further remarks are necessary. A few measurements of the specimens from two different localities in India are given.

	Calcutta specimens	Muktesar specimens
Length	0·085–1·3 mm.	0·62–0·67 mm.
Breadth	0·32–0·49 mm.	0·2–0·27 mm.
Spines on gonotyle ...	14–15, arranged in a fan-like manner and measuring 0·0075–0·040 mm.	14–15, arranged in a fan-like manner and measuring 0·006–0·033 mm.
Eggs	0·013–0·0275 × 0·012–0·026	0·024–0·028 × 0·013–0·014

SCLERODISTOMATIDÆ Dollfus, 1932
Syn. *ISOPARORCHIDÆ* Poche, 1925.
ISOPARORCHIS Southwell, 1913.

The genus *Isoparorchis* was assigned to the new family Isoparorchidæ by Poche (1925). Odhner (1927) and Fuhrmann (1928) did not approve of this procedure. They placed *Isoparorchis* in the subfamily Sclerodistominæ of the family Hemiuridæ. Dollfus (1932) raised the subfamily Sclerodistomatinæ to a family rank.

Isoparorchis hypselobagri (Billet, 1898).

This fluke appears to be a very common and widely distributed parasite both in the adult and immature forms. In India Southwell (1913) obtained these flukes from the gas bladder of *Wallago attu* and described them as *Isoparorchis trisimilitubis*. Kobayashi (1915 and 1921) obtained these worms from *Parasilurus asotus* and *Pseudobagrus auran-*

ticus in Japan and designated them *Leptolecithum eurytremum*. Travassos (1922) regarded the genus *Leptolecithum* Kobayashi as a synonym of *Isoparorchis* Southwell. Bhalerao (1926) on the basis of a comparative study expressed the opinion that the Indian and the Japanese forms are identical, while Johnston (1927) and Odhner (1927) preferred to retain Kobayashi's species as a second representative of *Isoparorchis*. The same year Johnston (1927) described a third species of *Isoparorchis*, *I. tandani*, from the Australian siluroid fish, *Tandanus tandanus*. Bovien (1927) recorded *I. eurytremum* from Java. Yamaguti (1933) obtained these parasites from *Parasilurus asotus* in Japan and as a result of a careful examination found that all the authors quoted above have been dealing with one and the same parasite, *viz.*, *Isoparorchis trisimilitubis*. Ejsmont (1932) had already pointed out that *Distomum hypselobagri* (Billet, 1898), *I. trisimilitubis* Southwell, 1913, *Leptolecithum eurytremum* Kobayashi, 1915 and 1921, *I. eurytremum* (Kobayashi, 1915), Travassos, 1923 and *I. tandani* Johnston, 1927, were all synonyms of *Isoparorchis hypselobagri* (Billet, 1898).

Besides the piscian hosts of this parasite referred to previously Chandler (1928) recovered these flukes from the stools of a human patient in Calcutta who was treated with an anthelmintic. Faust in 1929 also recorded the presence of this parasite in Man in Hunan Province in China. The writer (Bhalerao, 1932) recorded these parasites from the stomach of a crocodile in Assam who had a meal of some siluroid fishes.

In regard to the immature forms of this parasite a large number of piscian hosts are known from India as well as from Japan. Captain Parker in 1910 had obtained these from the muscles of *Barbus tor*. Figures published by Southwell and Prashad (1918, Figs. 4 and 5) of the worms from the lateral muscles of *Ophiocephalus striatus* are evidently those of *Isoparorchis hypselobagri*. The writer also recorded in 1932 these parasites from the muscles and cœlomic cavity of the same fish in Nagpur. Since this date the writer had an opportunity of examining this fluke collected from the mesentery and liver of *Notopterus notopterus* and from the muscles of *Ophiocephalus marullus*, *O. punctatus*, *O. gachua*, *Gobius giuris* and *Mastacembelus armatus* in Hyderabad (Deccan) and from the liver, body cavity and the subcutaneous tissue of *Ambassis nama* in Poona. Yamaguti's experiments in 1933 show conclusively that in Japan the intermediate hosts of *Isoparorchis hypselobagri* is *Mogurnda obscura*

and the other probable hosts are *Hypomensus olidus*, *Richardsonius hakonensis*, *Leuciscus hakonensis* and *Sarcocheilichthys variegatus*.

Summary.

In the case of the species *Pleurogenes gastroporus* observations are recorded in regard to the excretory pore, the position of the receptaculum seminis and the shell gland and the relative size of the suckers. The tendency to form new subspecies is deprecated.

The new species *Ganeo korkei* has been described and separated from the allied species. Its specific diagnosis has been given.

Ganeo tigrinum has been recorded from *Rana tigrina* in Nagpur.

In the case of *Mehraorchis ranarum* observations have been recorded with regard to the position of mouth and oral sucker, prepharynx, pharynx, intestinal fork, testes, ovary, receptaculum seminis, uterus and the excretory bladder. Measurements of the material from Nagpur have been given.

The new species *Prosthodendrium pushpai* has been described and separated from the allied species.

The formation of the new genus *Prosthodendrium* Dollfus, 1931 for the species having vitellaria anterior to testes and retention of *Lecithodendrium* for those having vitellaria posterior to testes has been approved of. The genera *Mesodendrium* and *Acanthatrium* have been considered to be synonyms of *Lecithodendrium* and *Prosthodendrium* respectively. Reasons for so doing have been given.

A key to the species of the genus *Prosthodendrium* has been given.

The species *P. cordiforme* from *Nyctinomus plicatus* in Rangoon and *P. ovimagnosum* from *Nycticejus pallidus* in the Punjab have been recorded.

The species *Opisthorchis noverca* from the wild dog, *Cyon dukhunensis*, in Calcutta has been studied and found to possess a prepharynx and no spines on the cuticle. Typical *Opisthorchis noverca* from a dog in the Punjab has been recorded.

Echinochasmus perfoliatus from cats in Calcutta and Muktesar has been recorded.

The non-tuberculate variety of *Schistosoma spindalis* has been recorded from a calf in Coorg.

Halipegus mehransis has been recorded from *Rana tigrina* in Nagpur

and in view of the variations occurring in this species the variety *minutum* has been abolished.

Halipegus sp. has been recorded from the intestine of *Rana tigrina* in Nagpur.

A critical review is given of the various species of *Haplorchis* (Heterophyidæ) recorded so far. The species *H. taichui* from cats in Calcutta and Muktesar has been recorded and measurements of a few of its organs given.

History of the discovery of *Isoparorchis hypselobagri* is given and a few more hosts harbouring the larval forms are recorded.

Acknowledgments.

It is the most pleasant duty of the writer to express his indebtedness to Dr. P. A. Maplestone, Dr. V. T. Korké, Prof. M. A. Moghe, Prof. J. N. Karve, Dr. Kalappah, Dr. S. A. Gunavardana, Mr. Abdus Salam and to the Director, Central Research Institute, Kasauli, for the gift of the material dealt with in this paper.

The writer is grateful to Professor R. T. Leiper, F.R.S., under whose supervision the whole of this work was done.

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Journal of Helminthology, Vol. XIV, *No.* 4, *December,* 1936, *pp.* 229-232.

Preliminary Observations on the Infectivity of *Ascaris lumbricoides* to Swine.

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The question of the immunity of the pig to ascariasis has been considered by helminthologists for some years and is still a vexed question. Ransom (1922) was of the opinion that the pig became immune at the age of 4 months but this was refuted by Morgan of the Institute of Agricultural Parasitology who, in 1931 successfully infected pigs at the age of 10 months and by the present writer (1934) at the age of a year. Sandground in 1929 referred to the difficulty of establishing infections under normal conditions though it is well known that almost every pig under field conditions picks up an infection at an early age. Furthermore, it is notoriously difficult to keep pigs "clean" for experimentation though this can be done, as it is done here, by careful attention to detail during rearing.

In 1934, eight pigs bottle-fed from birth and free from infection were experimentally fed with a large number of eggs of *Ascaris lumbricoides* of pig origin. Only four infections resulted. This result and numerous other similar negative ones led to an investigation of the details of experimental feedings and an interesting observation seems to have been forthcoming. The facts given below are, however, of a preliminary nature and further results are expected shortly.

A number of pigs of various ages and of known past history were available for experimentation. The Ascaris eggs were all of swine origin.

Two pigs aged 8 weeks were fed with a large number of infective eggs of *Ascaris lumbricoides*—the actual number is not known—in an emulsion in water. No symptoms of their migration through the liver and lungs were observed and no eggs were demonstrated in their faeces during the next four months. Unfortunately the faeces of these pigs were not examined immediately after the experimental feedings so that there is no evidence as to whether the dose was passed out intact as eggs or whether the larvae were hatched and passed out either dead or alive or if finally

they were retained within the body. Later these two pigs, at the age of 6 months, were again fed an enormous number of eggs in water as before. The number this time must have run into many thousands as the culture was nearly 100 per cent. infective. This time it was soon obvious that the infestations had been successful. One pig died 6 days later, following symptoms of pneumonia. Larvae were recovered from both liver and lungs in large numbers simply by teasing the organs in physiological saline and the tissues all showed the lesions usually associated with Ascaris migration. The other pig survived this ordeal and later survived a severe attack of diarrhoea lasting about a week, caused it is suggested by the appearance in the small intestine of a large number of active Ascaris larvae, each producing toxic substances. When the metabolism of the host had become restored, its general health improved and the course of the Ascaris infection was uneventful. The pig became " clean " again in 23 weeks and a month later was successfully infested again with Ascaris eggs.

Some time later four clean pigs, 11 weeks old and reared from a clean sow were available for experiment and these were then fed with Ascaris eggs. On this occasion, however, a different technique was adopted and it was aimed at approximating the method to more natural conditions. Therefore a number of small doses were given daily. The only eggs to hand were rather old and the culture was not more than 50 per cent. infective. Twice a day for 10 days 200 infective eggs were introduced into the food of each individual pig, giving a total of 4,000 eggs, with an experimental error of not more than 5 per cent. Empty shells were observed in the faeces following administration. There was no reaction until the fourth day when the pigs were less inclined than usual for their food. Though this condition persisted for another 12 days, it was never actually necessary to resort to forcible feeding and they afterwards picked up and ate normally. Between the sixth to the twelfth days after the first feeding, they were lethargic and tended to lie about in their bedding all day. One pig showed no further symptoms but the other three developed a persistent cough and the breathing was definitely laboured. At the end of a fortnight after the first dose and 4 days after the last, the symptoms began to moderate and the animals made an uneventful recovery. Ascaris eggs were later demonstrated in the stools showing that the infections had been successful.

Four thousand eggs cannot be said to be a heavy dose yet in all cases infestations resulted and there were definite symptoms of pneumonia. Later another pig, aged 9 weeks, was fed Ascaris eggs, 200 at a time, once a day in the food, making a total of 2,000. This animal also developed a slight cough with respiratory difficulties. This dose was very small and the susceptibility of the animal may have been due in part at least to the fact that it was the smallest one of the litter though it was perfectly normal and healthy.

This recalls the experiment published by Koino in 1922, when a young man 21 years old showed severe pneumonic symptoms following a dose of 500 eggs of "*Ascaris suum*" from the pig. Similar symptoms were observed by Koino himself after he had swallowed 2,000 Ascaris eggs of human origin. Following severe pulmonary symptoms, he obtained 667 worms after treatment—roughly 33 per cent. While as early as 1888 Lutz fed a human patient 100 eggs and later obtained 35 immature Ascaris worms—a percentage closely approximating to that obtained by Koino. He incidentally remarks on symptoms of pneumonia which occurred after the feeding which, however, he did not associate with the helminths. If this proportion of 33–35 per cent. holds good for all animals, including the pig, it means that there were at least 750 larvae in the lungs, in which pathogenic symptoms were seen. There were, however, probably more as there would certainly be some mortality between the lung and mature stages.

Owing to the fact that several members of the staff of the Institute developed a sensitivity to the presence of Ascaris, the experiments were broken off here temporarily but they are now being resumed on somewhat more intensive lines. These present results are therefore essentially of a preliminary character but they would seem to suggest that a very hopeful method of inducing an infestation with *Ascaris lumbricoides* in the pig is by means of a series of small comparatively insignificant doses. For a single dose to be infective, it would seem necessary to make it enormous when there is a great danger of producing a fatal pneumonia due to the migration of the larvae through the lungs. Resistance of the pig to Ascaris is of a doubtful nature so that immunological reactions are not likely to affect the method. If there is a resistance it is slight and of a temporary value for as has been shown, it is possible to effect infestations in adult pigs. Second infections also may be induced very shortly after

the first has been lost or even while it is still resident in the body of the animal. That there is something of the nature of a self-cure, however, is indicated again by Morgan's experiments in which the worm burden was completely lost although there was every opportunity for re-infection. This suggests that there may be some degree of acquired immunity.

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Journal of Helminthology, Vol. XIV, *No.* 4, *December*, 1936, *pp.* 233–235.

A note on the occurrence of *Anguillulina dipsaci* (Kühn, 1858) on certain weeds, including a new host record.

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The sudden occurrence of severe attacks of *A. dipsaci* on cultivated plants has never been completely explained. Goodey (1933 and 1936) has summarised the information on the subject of seed-borne infection by means of the seeds of cultivated and wild hosts. The same writer also suggests that weeds may play an important rôle in maintaining an active eelworm infestation in the soil by acting as hosts for strains of the eelworm capable of producing diseased conditions in cultivated crops.

The present writer has had the opportunity of making observations on fields of oats and beans badly attacked by *A. dipsaci*, and during the course of these studies the occurrence of the eelworm has been noted on two weeds, namely cleavers (*Galium Aparine* L.) and chickweed (*Stellaria media* Cyrill.). The latter plant is listed by Goodey (1933) but the occurrence on cleavers noted by the present writer constitutes a new host record. The writer first obtained infested specimens of both weeds in Spring, 1936. The weeds were commonly occurring in a crop of Spring oats badly affected by the eelworm. The field from which the plants were collected is situated in a district in North Yorkshire where stem eelworm disease is prevalent even when a rest of three years is maintained between successive oat crops. No difficulty was experienced in obtaining from this field infested specimens of both species of weed during the course of the season. It was difficult to recognise any definite symptoms in infested chickweed, but all infested cleavers plants showed yellowing of the lower leaves without any signs of swelling or distortion of stem or leaves. It is worthy of note that according to Goodey (1933) discoloration of leaves may be the only symptoms produced by *A. dipsaci* on *Calceolaria integrifolia* and *Primula vulgaris*. Two further interesting observations were made on the same farm. A

portion of the field which carried the diseased oats was under barley following wheat and specimens of the weeds found growing among the barley proved to be infested. In an adjoining field carrying turnips a few infested plants of both species were obtained. These findings are highly suggestive that the two weeds may be partly, if not wholly, responsible for the persistence of the oat strain of *A. dipsaci* on such a farm. It should also be noted that the occurrence of the eelworm has been noted by the writer on chickweed growing among infested oats at another centre in North Yorkshire, and also on cleavers collected from an oat field in East Yorkshire to which reference will be made later.

The discovery of infested cleavers plants among field beans severely injured by *A. dipsaci* raises some interesting questions both with regard to weed carriers of the eelworm and the bean strain of the parasite. The writings of Bos (1888-1892) suggest that such a relationship exists in referring to outbreaks of stem eelworm disease in beans following badly infested oats. Two cases observed by the writer in 1936 may be quoted. In the first case a field of beans in the East Riding of Yorkshire suffered so badly from eelworm attack that it was ploughed in. Cleavers was a common weed and infested specimens were readily obtained. The second case occurred at another centre in the East Riding. One half of the bean crop followed oats and the eelworm injury was such that the beans were ploughed in. The other half followed barley, and although the bean crop was allowed to stand it carried extensive patches of disease which by late Spring were almost devoid of plants. Infested cleavers plants were numerous among the beans. The ploughed half of the field was inspected in early July and among the weed seedlings growing on the fallow there were numbers of very young cleavers seedlings, some of which showed signs of early infestation by *A. dipsaci* on the cotyledons. An infested cotyledon possessed a small chlorotic spot continuous with a discoloured lesion extending along one side of the petiole to the main stem and slight distortion was noticeable in that one side of the cotyledon was slightly smaller than the other. The fact that the cleavers seedlings were infested after ploughing in the infested bean crop lends weight to the inference drawn from the other field observations that the weed is probably a host for the bean strain of the eelworm. Finally, since the same weed carrying eelworm infection

occurs both among infested oats and beans it would seem that the suggestion that the oat strain and the bean strain are related is also a possibility. It should be stated that on the second farm referred to, inspection of a field of oats adjoining the affected bean field revealed that the oats were infested by the eelworm although the injury was not severe and in addition infested cleavers plants were obtained.

The field observations recorded above appear to add to our knowledge of the bionomics of *A. dipsaci*. It is clear, however, that further research is required to establish with certainty the part played by weed hosts in relation to the persistence of *A. dipsaci* infection in crops of oats and beans. The writer has already commenced investigations with this end in view.

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Errata.

Page 163, for "*EURETREMA*" read "*EURYTREMA*."
,, 164, line 8 from bottom, for "*Patynosomum*" read "*Platynosomum*."
,, 174, for "*MESOCLEUM*" read "*MESOCŒLIUM*."
,, 174, for "*Mesocœlium leiper* n. sp." read "*Mesocœlium leiperi* n. sp."
,, 176, line 10 from top, for "*micron*" read "*microon*."

PRINTED IN GREAT BRITAIN.